

THE VEGETABLE OIL INDUSTRY

A treatise for manufacturing oils from the Indian
oil seeds with detailed processes of filtering,
refining, bleaching, deodorising and
hydrogenating the oils.

By

AN INDUSTRIALIST

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INTRODUCTION.

RECENT developments in the industrial world have greatly stimulated the demand for oils from vegetable sources. In the course of a quarter of a century the production of oils of commerce has made considerable progress and still it appears that the supplies of oils, specially in certain groups, are not keeping pace with the growing demand for the oils. This is partly due to the large use of the oils in the manufacture of soaps, paints, lubricants, etc. and partly due to the increasing demand for edible fats, brought about by the shortage in the supplies of butter.

PLIGHT OF THE INDIAN OIL INDUSTRY.

Only a few decades ago oils in India were chiefly of interest as articles of diet or as illuminants. The only other important use to which oil was put was the anointment of the person and for that purpose only mustard, coconut or other sweet oils were used, and the practice continues to this day.

The advent of cheap kerosene oil and mineral oils has brought about a complete change in the whole outlook of the Indian oil industry. It at once resulted in a curtailment of cultivation and expression of most of the minor seeds, more especially those intended as illuminants and lubricants. The wealthy people still employed castor or coconut oil for illumination pur-

poses. But the subsequent introduction of refined kerosene oil, gas and electric light drove the vegetable oils out of use, and that too within a comparatively short time. The coming of cheap lamps in the market may be said to have marked the complete displacement of vegetable illuminating oils.

INDUSTRY GETS A FILLIP.

But the numerous industrial uses to which the oils are put now-a-days have once again lent a fillip to the vegetable oil industry in India. A part of the oils of commerce is now employed for the manufacture of the edible fat, and the proportion so used is steadily increasing. Oils, such as those of rape seed and linseed, which have until recently only been used for industrial purposes in Europe can now be so efficiently refined as to be employed in making margarine, and large quantities of rape seed oil have been used in this way in recent years, especially in the Continent. Cotton seed and other oils can now also be converted, by a process of hardening by hydrogenation into solid fats, thus adding to the world's resources of solid fats suitable for edible purposes.

No-less important is the use of oils and fats in the manufacture of soap, in the course of which glycerine is separated as a bye-product. As it is essential for the manufacture of modern propellant explosives, there is no need to enlarge on the importance of this branch of the industry. The candle industry also consumes a large quantity of stearine and solidified oil.

Large quantities of oils and fats are also used as lubricants, and in this connection special reference can be made to castor oil, which is the lubricant *par excellence* for aeroplane and similar work, and is therefore a war material of first rate importance.

Mention must also be made of the varnish and paint industries, for which drying oils, such as those of linseed and poppy seed, are essential. Large quantities of special oil varnishes are used in the production of highly explosive shells.

Finally, the residues—cakes and meals—left after the expression or extraction of oils and fats from oil seeds constitute an asset of ever-increasing importance for feeding cattle, and are therefore indirectly of great importance as food for human beings.

INDIA'S OIL RESOURCES.

It is, however, fortunate that so far as oil seeds of commerce are concerned, India is most favourably situated. Her resources of oil seeds are enormous and are capable of further expansion by the introduction of better seeds and more enlightened agricultural policies. With the exception of palm kernels and olive, India makes an important contribution to all the principal kinds of oil seeds which form the basis of the world's oil seeds crushing industry, and it is admitted that Indian oil seeds on the whole compare well with those produced elsewhere, and in some cases, e.g. copra, linseed, etc., the Indian oil seeds for practical purposes represent the best grades in the market.

Indian production of oil seeds which comprise linseed, groundnut, cotton seed, castor, sesame, rape and mustard, mahua, copra, etc., on a conservative estimate, exceeds 3 million tons annually. This, besides satisfying in full the local requirements for Indian industries and home consumption, leaves huge surplus for exports.

Indian seeds also being generally of good quality have met with wide recognition in the international markets where Germany, France, Italy, the United Kingdom, and other principal oil crushing countries

are the biggest purchasers. Indian seeds have been so long being eagerly sought after on the world's market and in the case of castor and mahua seeds India holds a virtual monopoly.

INDIA'S POSITION IN THE WORLD TRADE IN OIL SEEDS.

The great part that India plays in the world's oil seeds market will be best illustrated by the table which shows the percentage of oil seeds supplied by India in the international trade:—

India's share in world's
trade of oil seeds.

Copra	7 per cent.
Mahua	100 "
Cotton seed	31 "
Sesame	42 "
Castor	98 "
Rape and Mustard	65 "
Groundnut	45 "
Linseed	20 "
Poppy seed	76 "
Niger seed	100 "

SCOPE FOR IMPROVEMENTS.

The oil industry as it exists in India to-day leaves much room for improvement. It is rather astonishing that in these days of industrial progress India still rests contented with processes which are mostly crude and unscientific and lead to enormous economic losses. The country oil mills, commonly known as *ghanies*, ply in the country with their characteristic cracking sound and there is no intention among the oilmen to replace them by modern machines to get an improved outturn. They do not know that the oil cake which is left after

pressing in the *ghanies* still contains an appreciable quantity of recoverable oil, while the existence of an excess of oil in the cake makes it of little value as an ideal cattle food or manure. This involves losses on two heads, viz. loss of oil which is retained in the cake and the loss in value of the cake due to the presence of excess of oil.

DEVELOP OIL MILLING INDUSTRY.

There is abundance of raw materials and the capital for rehabilitating the oil industry would not be too big for India to raise. The industry can be started on a moderate scale and does not require expert labour with high technical knowledge. Indian oils now find foreign markets to some extent. In 1939-40 the exports were valued at Rs. 112 lakhs as against Rs. 82 lakhs in 1938-39 and Rs. 75 lakhs in 1937-38. The volume of vegetable oils exported from India during 1939-40 amounted to 7.2 million gallons as against 6.2 million gallons in 1938-39 and 5.0 million gallons in 1937-38. Exports of groundnut oil and castor oil form the chief items. Compared with the figures for exports of seeds these dwindle into insignificance and leave an unlimited room for expansion. This unsatisfactory condition of the oil trade is mainly due to the inefficient and primitive modes of expressing the oil. The country *ghanies* may be acclaimed as the best machines in the case of crushing some seeds, such as sesame, rape, etc. but improved methods can be adopted in crushing other seeds. This will not only yield a higher quantity of oil but also of superior quality and will thus leave smaller quantity of oil present in the cakes, which is a desideratum to be attained. This increases their utility as a fertiliser and a cattle food. By the bye it may be stated that enormous quantities of oil-cakes are exported to foreign countries which econo-

micallly press out the oil still remaining in the cakes for use in the soap and allied industries and then sell the cakes thus rendered more suitable as fertiliser and cattle food at profitable prices.

RESTRICTIONS ON SEEDS EXPORTS.

It is time that India uses her own resources of oil seeds in her oil mills and discourage exports of oil seeds for various reasons. Arguments in favour of restrictions may be resolved under three main lines:—

1. The export of oil seeds is impoverishing India, particularly the seed producing centres, by way of loss of oilcakes, which are invaluable as cattle foods and fertilisers.

2. The exports are depriving the local labourers and local capitalists of the profits of pressing out the seeds into oils.

3. By crushing the fresh oils in India better oils can be produced than are now obtainable from stale oil-seeds from Europe.

The soundness of the reasoning is evident. Immense has been the economic loss to the country due to the unrestrained exports of oil seeds. It looks strange that foreign oils made from imported seeds are placed on the Indian markets at prices lower than the locally expressed oils. Why does such deplorable state of affairs obtain in India?

UNHEALTHY SYSTEM OF FREIGHTS

The existing system of railway freights is not a little responsible for such unhealthy economic condition. Lower railway rates for oil seeds and higher for oils have encouraged congestion of seeds into the port towns for shipment to foreign countries and local expression of oil by mills. It may be mentioned in this connection that foreign countries as a general case

allow the import of oil seeds to take place free of duties to their countries but they penalise the imports of all oils by imposing heavy duties. They do this partly because they find it more convenient to import the seeds in bags than the oil in drums and partly because of the economic question involved therein. They would utilise the foreign raw stuff and keep their own men employed in the milling industry. It would have been another matter if India held the monopoly in the seed trade of the world and then she could have extracted every drop of oil before the seeds were shipped. Under the present circumstances the only way to stop exporting oil seeds is to start oil milling industries on a large scale and to find out new spheres of their utility in the Indian market and their possible applications in various branches of trade and industry.

It may be contended that the industrialised countries have all set up oil crushing factories and would prefer importing the seeds in bags instead of importing the oil in drums, which entails greater transport difficulties and bigger freight charges. But that is the view point of the foreigners, who do not produce the seeds but must have the oil for the manufacture of various articles including edible fats and for lubricating their machines. India being a very big factor in the world's oil-seeds trade, may express the oil, at least of a portion of the seeds, before these are actually shipped out. This is destined to lay out the foundation of a valuable industry in India offering employment to her teeming population wanting their daily bread and at the same time this will put a stop to the imports of foreign oil. Even if the Indian oil cannot at first be pushed in foreign markets on a big scale the expanding industries of India would require them in large quantities and make a distinct outlet for them. There are at present about 200 big oil mills employing

10,000 hands but the number is too insignificant to cope with the problem.

CHEAP TRANSPORT FACILITIES.

It would thus appear that to develop the oil industry in India, which from the point of view of food, feeding stuff and raw products for manufacturing industries is a vital necessity, the essential point to be attained is a free movement of the oil seeds and oils from place to place and re-organisation of the milling industry. To facilitate the seeds trade all possible steps should be taken to secure cheap transport facilities between different parts of the country. In some cases the Railway authorities should be required to reduce transport rates on the home-made article, and in general in arranging rates, the railway authorities should observe the principle of charging on home-made goods only what the traffic will bear, with due regard to the competition of similar imported articles.

The cost of internal transport of oils can be materially reduced by the use of tank wagons. Such wagons cannot, however, be used for the highest kinds of the refined oils, owing to the risk of contamination but there is no doubt as to their suitability for the transport of industrial and unrefined oils. A large number of tank wagons should be provided by the railway authorities and this in fact should become the useful means of transporting industrial or unrefined oils and fats.

SUGGESTIONS FOR IMPROVEMENTS.

To consolidate the position of the Indian milling industry, oil-seed crushers should be encouraged to replace old plants and remodel their mills. There also remains much room for improvement of the milling

processes and unless these are effected the Indian variety of oil will never come to the prominence for external demand. We mean that the seeds, specially in the case of cotton seed and groundnut should be decorticated before being expressed as is the custom in the American mills; the whole seeds are crushed in India and this is one of the main reasons which restrict the use of the Indian variety of oil to soap making and allied industries only and prohibit its general application as an edible oil. Of late due to the great demand of the edible variety of the cotton seed oil, during the world shortage of olive oil and scarcity of butter, Egyptian mills have effected desirable improvements in the method of manufacture, thereby getting a sound footing in the world's cotton oil trade. In India also similar improvements would not be beyond the capacities of the mills and if done, this will usher in a new era for the expansion of the Indian cotton seed trade.

Indian oil-seeds are not always marketed in clean and good condition and are liable to contain dirt and foreign seeds, which prejudicially affect the oils and their selling values. This is a defect which should be remedied by all means. Special action is also necessary in the case of groundnuts. The nuts are still generally shelled in India by a process of wetting, whereby serious deterioration is caused in the kernels. The remedy, machine-shelling, is already being applied with success; but the bulk of Indian groundnuts are still shelled by the old method. As a result most of the Coromandel nuts are used only for the production of industrial oils. It is most important that machine-shelling of groundnuts should become the general practice as soon as possible, if India is to manufacture groundnut oil for edible purposes.

CHAPTER II.

OIL SEEDS IN INDIA.

INDIA probably produces in commercial quantities a greater variety of oil seeds than any other country. The following are the most important oil seeds, classified under three groups, according to the nature of the fat or oil contained.

CLASSIFICATION OF OIL SEEDS.

The following classification of oil seeds is of interest especially in connection with the technical uses of the oil.

Yielding solid fat—

- (1) Copra; (2) Mahua.

Yielding liquid non-drying oils—

- (1) Cotton seed; (2) Sesame seed; (3) Castor Seed; (4) Rape seed; (5) Groundnut.

Yielding liquid drying oils—

- (1) Linseed; (2) Poppy seed; (3) Niger seed.

OIL CONTENTS OF THE SEEDS.

From the point of view of the oil-seed crusher, it is however more convenient to classify them according to the yield of fat or oil, as follows:

Group A—Seeds rich in oil, i.e. containing 45 to 70 per cent. of oil, viz., groundnut, sesame seed, mahua seed, castor seed, copra.

Group B—Seeds less rich in oil, i.e., containing from 13 to 40 per cent. of oil, viz., linseed, rape-seed, cotton seed, niger seed, poppy seed.

Importance of this method of classification lies in the fact that different types of oilseed pressing plants are required for the two groups. Oilseeds belonging to Group A are not generally expressed while seeds belonging to either group may be easily extracted with the help of solvents.

PRODUCTION.

The majority of the oil-seeds and oil-yielding materials are regular agricultural crops. A few, such as the coconut, the mahua, the palm, etc., are however trees and can hardly be classed as agricultural crops.

The annual production of oilseeds totals about 5 million tons, the chief of which are linseed, rape and mustard, sesamum, castor seed and groundnut. There are minor seeds which are also cultivated on a fairly big scale some of which possess great medicinal values.

A description of the habitat of the seed-bearing plants, the varieties of seeds, the uses of seeds and of the oil derived from the seeds follows:—

LINSEED.

Linseed is the seed of the common flax or lint, botanically recognised as *Linum usitatissimum*.

India's resources of linseed are quite enormous. The principal provinces where linseed is grown are in order of their importance, Bihar and Orissa, United Provinces, Central Provinces and Berar, Hyderabad; Bengal, Bombay, Kotah and the Punjab. The United Provinces and Bihar between them carry about half the total acreage under linseed but the types grown are inferior as regards size of seed and oil-content to those grown in Peninsular India.

In buying linseed for pressing note should be made that the linseed of commerce is generally grouped under two heads: yellow and brown. The brown oil seed in trade circle is further divided according to the size as bold, medium or small. Yellow seed is mostly traded in admixture with bold brown linseed as the total crop is a very small quantity as compared with the total production of linseed, this being generally less than 5,000 tons annually. Moreover linseed is subject to extensive and detrimental adulterations resulting not only from careless harvesting but also from direct admixture with cheaper and inferior oil seeds, such as wild rape, mustard, sesame, poppy, etc., etc.

The oil content of linseed varies considerably according to the source of origin and the season of harvesting. It may, however, be averaged at 30 to 40 per cent.

Apart from its value as a source of oil, the seed is not a product of much economic importance. The oil obtained from the seeds, known as linseed oil, has met with extensive uses due to its drying properties in the manufacture of paints, printing inks, floor cloth, vulcanised rubber, oil varnish, and soft soap. The oil is also to some extent put to human consumption. The cake serves as a manure and is used as a valuable cattle feed.

The oil occurs in various shades of colour (from yellow to light orange), has a specific gravity of 0.935 at 15°C and 0.881 at 100°C, the flash point being 103-140°C. The oil requires for complete neutralisation 18.9 per cent. of its weight of caustic soda. This has got the additional property of giving soft and transparent soaps. The glycerides of linolenic acid and iso-linolenic acid constitute 60 to 70 per cent. of the oil.

• Pure linseed oil boils at 600°F., attracts the oxygen and becomes heavier, and is quicker in drying. This operation is commonly known as “drying” the oil; if the oil is boiled twice it is called “double boiled” linseed oil, and gets much thicker. It matters not how pale or colourless the oil may be before boiling; it becomes darker by the continued application of heat in the boiling.

GROUNDNUT.

• Groundnut, variously known as earth-nut, pea-nut and monkey-nut, is the fruit of *Arachis Hypogaea*. It is rich in oil, the percentage of oil recovery exceeding 40 per cent.

The groundnut flourishes in Madras and Bombay Presidencies, over sixty per cent. of the area under cultivation being in Madras. In Madras the centres of production are Arcot, Chingleput and Bhavani and Cauvery Valley. In Bombay—Poona, Sholapur, Satara, Khandesh, Karnatak and Kolhapur are the main producing districts.

As a general rule the crop is sown from May to August and is harvested from November to January. A summer variety is also grown in Madras forming 5 per cent. of the total area under the crop. This variety is sown in February-March and harvested in July-August. It may be added that as a general rule Bombay crop comes in season in November and the Madras crop six weeks after on the average. This is therefore a fact of considerable importance which the buyers of Indian nut should bear in mind.

• The nuts owe their popularity to their nourishing dietary value and equally to their cheapness. The seeds when fresh are largely eaten in tropical countries. The oil, expressed from it, is limpid, of light yellowish or straw colour and possesses a faint smell and bland

taste. The oil is used for lighting purposes and as fish or curry oil and for medicinal purposes. In Europe it is considered as a good substitute for olive oil; in India it is used in the adulteration of sesame oil. Application of the oil in the soap industry is also great.

Seeds may be brought from the market either in the decorticated or undecorticated state, which means shelled or unshelled. The seeds without the shell weigh only 75 per cent. of the seeds with the shell on.

Cold drawn ground nut oil is a pale limpid liquid of pleasant taste and is mainly used for edible purposes. It contains less than 1.0 per cent. of free fatty acid. The second and third pressure oils are exclusively used by the soap manufacturers.

The oil contains the glycerides of arachidic, lignoceric, palmitic, oleic and linolic acids. Its specific gravity varies from 0.917 to 0.919, solidifying at 2°C. It gives a soap of white soft body, the colour depending upon the grade of the oil used. It requires 13.56 to 13.93 per cent. by weight of caustic soda or 19.13 to 19.93 per cent. by weight of caustic potash for neutralisation.

The cakes are of no mean value. These are used principally as cattle food and reports are to hand suggesting that these can be converted into various palatable forms of human food.

CASTOR SEED

The castor plant belongs to the botanic species *Ricinus Communis*. The principal provinces where the castor flourishes most are Madras, Nizam's Territory, Bombay, Central Provinces, United Provinces, Bihar and Orissa.

Castor is harvested from January to February and the late variety which is grown in September is harvested in March and April.

The seeds are distinguished according to their size and place of origin. In the market distinction is made between the bold seed and the small seed, although there is a third variety known as medium. The principal varieties known in the market are Bombay small seed. Madras small seed, Cawnpore and Calcutta. Many other varieties are known in addition to these, mostly named after the place they hail from. The Mullikottai variety found in the Coimbatore District is of small size, Godavary and Kistna varieties are alike, being small and grey in colour. They find much favour in the Calcutta market owing to the quantity of oil which they yield. Salem variety is the largest of the Madras seeds and is red in colour. The Bellary seed is of medium size and is also red. And similar classifications occur for other places. The varieties are often given name after the season when these are sown, as in Bengal, where the seeds are known as *bhadoi* or *basanti*, *bhadoi* being grown with *bhadoi* crops and *basanti* being sown in the spring.

As regards selection of seeds, this is to be made according to the purpose to which the seeds are intended to be put. Small seeds generally afford the superior qualities of oil of commerce including the medicinal oils while the larger seeds yield on extraction an oil which is used as illuminant and also for the manufacture of lubricating oils.

The oil extracted from the seed which varies from 40 to 50 per cent. of the seed is the best for lubricating all sorts of machinery, clock, watches, etc. It has been reckoned on all hands to be the best lamp oil we have in India, and gives an excellent white light far superior to that of mineral oils, petroleum, rapeseed,

mustard, linseed and all other oils whether vegetable, animal or mineral. Its freedom from danger as lamp oil is another recommendation. It gives out very little soot, almost imperceptible, which quality no other lamp oil possesses. This is a great recommendation, the most important being that besides being one of the cheapest lamp oils it is largely employed in the manufacture of all kinds of soaps, candles, pomades, and perfumed oils. Perfumers use castor oil, because of its demulcent quality, which keeps the head cool and the pores of the skin and roots of the hair soft and open. Moreover it is a medicinal oil and the most largely used as a mild demulcent laxative. The cold drawn oil gives splendid light; when boiled it does not give such splendid light for in the boiling or sweating, or both processes, the electric light-giving portion of the oil gets dissipated to a certain extent. The advent of the kerosene oil and electric lighting system has told heavily upon its consumption. But this has been compensated for to some extent by its industrial applications. Besides being used as a lubricant, it is now employed in the manufacture of Turkey-red oil, required in the dyeing and printing of cotton goods, in the preservation of leather belting and in leather industries. Formerly olive oil was employed for the purpose, but it has now been almost entirely replaced by castor oil. The oil can be used alone or in conjunction with other oils in the manufacture of soaps.

Castor oil varies in colour from light yellow to dark brown, and possesses a characteristic smell and its specific gravity ranges from 0.960 to 0.970. It solidifies at -18°C . It takes from 12.5 to 13.3 per cent. of caustic soda to saponify it.

The most important constituents of castor oil are the glycerides of ricinoleic and dihydroxy stearic acids.

•The castor cake is of very considerable value as a manure though it is regarded by cattle breeders as highly injurious to cattle. The cake also serves as a useful fuel and it may be added here that in Mysore and other parts of India a special fuel is prepared which consists of a certain proportion of the oil cake or boiled seed mixed with cow dung. It is also used for caulking timber for destruction of white ants, and for stuffing the soles of shoes.

RAPE SEED.

Indian forms of rape, mustard and sarson which present almost similar properties are obtained from the species of *Brassica*. The seeds yield 40 per cent. of oil.

The cultivation of rapeseed is prominently restricted to the northern part of India, there being, so to speak, only limited area under tillage in Southern India. The principal provinces where rapeseed is grown are U. P., Bengal, the Punjab, Bihar and Orissa.

• In the U. P. it is grown under two heads pure and mixed. The area shown as pure is under *toria*. In the Punjab the crops are grown in Ferozepur, Hissar, Jhelum, Rawalpindi, Dera Ismail Khan, Lahore, Gujrat, Dera Gazi Khan, Jhang and Karnal Districts. The crops are sown either in October or November and gathered in February and March and sometimes as early as January for the purpose of cattle fodder.

The principal commercial varieties of rape-seed are tori, brown bluish in colour chiefly exported from Karachi, Ferozepur brown, brown Cawnpore, chiefly shipped from Bombay, yellow bold and yellow small. There are other varieties known as Gujrat and Cawnpore variety, because of their being of local origin.

The rape oil is used extensively for culinary purposes in the provinces where it is in abundance. There is hardly a village in those provinces without a country *ghani* to express the oil. The oil is also used for burning and lubricating. The chief components of rape oil are the glycerides of the unsaturated rapic and erucic acids mixed with a little stearic, arachidic and linolic acids. The oil has a specific gravity of '914 to '917 and requires for saponification 17·17 parts of caustic potash for 100 parts of the oil. The refined oil is pale yellow in colour and possesses a typical smell. The oil cake obtained from press mill is an excellent cattle food while the extracted meal is only of use as a manure.

COTTON SEED.

Cotton seeds of commerce are grown in association with the floss of cotton. The boll of cotton is divided into from three to five compartments each containing a lock of seven to nine seeds to which the lint—the actual cotton—is attached. Previously the seeds were taken off by hand but the introduction of the saw gins has brought about a revolution in the history of cotton seed,

The seeds are either black or clean, or white or fuzzy. Indian seeds and the American Uplands are what are known as white or fuzzy owing to a short lint or fuzz with which the whole seed is coated and which is not removed by the process of ginning. On the contrary Egyptian and Sea Islands seeds do not possess any short green lint or fuzz except occasionally a small tuft of lint on the pointed end of the seed. The seed can be easily separated from the lint which comes out easily and therefore it is called "black or clean."

• Seeds may be grouped according to their degree of maturity as unripe, half ripe and ripe and according to their degree of inferiority as wet, musty or rotten. Cotton seeds are again divided into two general classes; prime seed and off seed. By prime seed is meant clean, dry, sound seed, free from dirt, trash and bolls. Seed not coming up to the requirements of prime seed shall be considered as off seed.

In India the commercial varieties met in the market are named after the country of origin. The varieties most known are Bombay, Delhi, Cawnpore, American, Comilla and Rangoon. The most well-known is the Bombay variety though in point of excellence it is surpassed by the American seeds. The other three types are regarded as inferior as they contain a large percentage of damaged and worm-eaten seeds.

The available quantity of oil from the seed is a very variable factor. The oil-yield varies according to crop and even season of milling from 17 to 30 per cent. As a general rule 35 to 42 gallons of oil is obtained from 1 ton of the seed. Physically, however, a ton of seed is said to be composed of short lint 75 lbs., hull 925 lb., oil 390 lbs. and meal 619 lb.; but in actual milling yield of lint and oil is considerably less in favour of hull and meal. It may be noted here that 1 gallon of the oil weighs $7\frac{1}{2}$ lbs.

Cotton seed oil is available in plentiful abundance in India in the cotton-bearing tracts. The refined oil or the cold expressed oil from decorticated seeds is of a pale yellow colour and may be used for cookery.

• The perfect edibility of refined cotton seed oil extends its use for every purpose for which animal fats are commonly used. Direct uses of refined cotton seed oil are as a table or salad oil, for packing sardines and as substitute for many purposes for which olive oil is

used. The common grade of oil finds also many useful employment for industrial purposes. It is used either alone or in conjunction with other animal or vegetable fats in the manufacture of soaps and candles. The oil has also found an outlet as miners' oil and is to a considerable extent displacing lard oil in this respect. It is of the semi-drying variety. The oil is in request in France and Italy to adulterate olive oil.

Cotton seed oil has a specific gravity of 0.922 to 0.926 at 15°C. The flash point of the oil is 475°F and it solidifies at 0°C to 7°C. It has a certain tendency to dry and congeals at 32° to 45°F. The oil requires 19.5 per cent. of caustic potash and 14 per cent. of caustic soda for complete neutralisation. Cotton seed oil yields a soap of thin body, darker than the tallow soap and comparatively easily soluble in water. The soap has a pale reddish tinge and a high detergent property but often gets rancid on long storage. The oil is much used in making pale soaps.

The oil appears to consist chiefly of the glycerides of palmitic, oleic and linolic acids.

Cotton seed cake and meal are extensively used as a fertiliser and as a valuable feed for cattle and sheep. The cotton seed forms also a useful cattle feed but its general use is not so fully understood.

SESAME OR GINGELLY.

Sesame is the seed of *Sesamum Indicum*. In India it is cultivated extensively all over the country, and especially in Bombay, Burma, Madras and Central Provinces. The seed also goes by the name of gingelly.

There are two crops, *rabi* and *kharif*, and various cultivated forms of the plant, some specially suitable for growing in the *kharif* season, others as early as

rabi crops. The rabi crop, if sown in September, is ready in January. The kharif crop ripens in October or November.

The commercial varieties of seeds are white, black, mixed, yellow and red, the first named being regarded as with the highest oil content. The black seed, however, is the more common form and is reputed to yield a superior oil. The average yield of oil from sesame is 42 to 45 per cent.

The sesame oil is extensively used for culinary purposes in Upper India and as an illuminant. The oil makes a good hair oil and serves as a base for many floral and perfumed oil meant for the hair. Of recent years new industrial applications of the oil have been discovered. The use of oil in making edible oils and fats is now obligatory in some Continental countries. The cake left after the extraction of oil is used as cattle feed and manure. It is admitted that the cake has valuable influences on the milk-yielding capacity of the cattle and reports are obtained as to the use of the cake as an article of human consumption in times of scarcity.

The oil frequently contains large quantities of fatty acids consisting of a mixture of about 78 per cent. of liquid acids (oleic and linolic) and 12 to 15 per cent. of solid acids (stearic, etc).

COPRA.

Coconuts grow abundantly in India. More generally the regions suited to coconut cultivation may be said to be the lower basins of the Ganges, Brahmaputra and Irrawaddy, also the Malabar and Coromandal coasts and adjacent islands—Madras Presidency being the chief producing area. Kathiawar, Kanara and Ratnagiri Districts of Bombay, and the native States of Tra-

vancore and Cochin are also centres where coconut grows abundantly.

Copra which is the trade name for the dried kernel of the nut, or ordinarily called as dried coconut meat, is an exceedingly important coconut product. The general method of production consists in first breaking the husked nuts into two equal parts. The coconut milk which is enclosed within the nut is then drained off and the two halves of the nut are then exposed to the sun. A few hours' exposure to direct sun would cause sufficient shrinkage of the meat so as to facilitate its removal from the shell, after which the meat is subjected with frequent turning to a further period of drying. In the opinion of experts four or five days' sun-drying will suffice but in some climates the process is continued considerably longer. Provision is often to be made against rains and recourse has been taken to drying trays with wheels running on rails for the purpose of running the trays under cover with as little delay as possible when rains set in.

DRYING COPRA.

Sun-drying especially if combined with a preliminary treatment with sulphur fumes to destroy fungoid growths yields good results but climatic conditions do not always render it practicable. It is often necessary to resort to artificial drying and the primitive method of smoke drying is still in much use, in which case the copra is dried on lattice trays over a slow fire, but the resulting copra is liable to be partially charged and darkened by smoke and yields an inferior oil.

Drying of copra is often done in shreds in kilns heated by means of a long furnace, the flue running under the floor. This may be constructed simply by digging a trench which is covered with sheet iron and

then with a layer of sand. Drying in a kiln of this type generally takes about 36 hours but naturally depends on various factors such as the turning of the copra. Probably the most economic method is that of drying in shreds heated by steam pipes but in the case of smaller plantations the initial outlay is often too great. A large number of drying machines of various types are on the market but primitive methods are still mainly in use. It is of urgent necessity that in every case the meat should be dried down to a maximum moisture content of 5 to 6 per cent. Otherwise the copra will be attacked by various micro-organisms which cause loss of oil, heating of the copra on storage, and a bad coloured oil.

The best Malabar copra is sun-dried in the sand by the sea shore or in cemented yards (known as barbecues) under nets, the process taking from 5 to 10 days and at seasons when non-liability to damage from rain is practically assured.

The oil is available in great abundance on the Malabar and Coromandel Coasts and the lower basins of the Ganges, the Brahmaputra and the Irrawady. The Cochin variety of the coconut oil is the most prized as being free from any free acids. Calicut and Alleppey varieties are also good.

Coconut oil has a pleasant odour, characteristic of its own. Its specific gravity is 0.93 at 15°C and 0.87 at 100°C. It melts at 20° to 25°C and remains in the liquid state for the greater part of the year. One great drawback which the oil suffers from is that it goes rancid on keeping and gives out an offensive smell. The oil consists of stearic, palmitic, oleic, myristic and lauric acids as triglycerides and contains small quantities of lower acids, butyric, caproic, etc. The yield of glycerine from coconut oil is also great, being 12 per cent. of the soap.

MAHUA SEED.

Mahua seeds are obtained from the fruits of Mahua trees, botanically known as *Bassia latifolia*. These are large deciduous trees found in abundance in dry and stony regions of Bengal and Bihar and in fact over the greater part of Central India. Another species of *Bassia* which yields a similar vegetable fat is *Bassia longifolia*, which is an evergreen tree met with in South India. These are locally known as *ippa*, *yeppa*, *illipi*, etc.

The season for collecting mahua seeds is very short, viz. from the middle of May till the break of the monsoon, and unless previous arrangements are made a large proportion of the crop becomes spoilt and is lost to commerce. The seeds should not be stored through the monsoon without being dried properly.

The seed when crushed by hydraulic presses yields about 33 per cent. of the oil. The mahua cake left after hydraulic expression is almost valueless.

The oil is much used in laundry and cheap toilet soaps on account of its low price. The oil has a pale yellow colour but oil of light yellow colour is also met with. It ranks now-a-days as one of the most important soap stocks and is generally used in conjunction with coconut oil, tallow, sesame oil, etc. It is often substituted for animal fat.

The oil is a mixture of stearin, olein and separated crystals of stearic acid.

POPPY SEED.

Poppy is the seed of *Papaver Somniferum*. The best oil is obtained from capsules that have not been lanced. They yield a sweet edible oil absolutely devoid, of course, of any trace of opium. The oil is largely used for culinary purpose, the lowest grades

being employed for lubrication or burning. Poppy oil is a good drier and is used for making candles, soaps, paints and artists' colours and also for cleaning delicate machinery. The yield of the oil, when the seed is fresh, is 13 seers per maund.

The residue of cake left after the oil has been pressed from the ripe seed is sweet and nutritious and used as a food for bullocks and sheep, but is not recommended for young stock, or cows. It is said not to keep well and to be liable to become mouldy and acrid to the taste, and is alleged then to be more or less injurious to cattle.

NIGER SEED.

The plant which produces the niger seed (*sorguja*) of commerce is known botanically as *Guizotia Abyssinica*. It is native to tropical Africa but is now cultivated in various parts of India.

In India niger seed is produced chiefly in Chota Nagpur, the Central Provinces and the Deccan. The crop is harvested in November or December.

Niger seed is largely crushed in India for the oil which is pale yellow, with little odour and sweet taste. The yield of oil is about 35 per cent. of the weight of the seed. The oilcake is highly appreciated for milch-cows in the Deccan and as a manure for the sugar cane crop. Mustard oil is adulterated with niger seed oil. While rape seed yields 20 gallons of oil per quarter of the seed, niger seed which dries up quicker, yields only 16 gallons per quarter but a mixture of *sorguja* with rape actually increases the yield of oil of the latter seed. Hence the general use of *sorguja* seed in many parts of India for mixing with mustard seed before pressing mustard oil.

Niger seed oil, owing to its comparative cheapness, is used for lubricating and lighting purposes and also for anointing the body. It is pale yellow or orange in colour, with little odour and sweet taste. In its drying properties it ranks between cotton seed and linseed oil.

PALM FRUIT.

Palm oil is obtained from the flesh or pericarp of the palm fruit (*Elaeis Guineensis*) and in India it is available plentifully only in Burma.

The palm fruit should be separated from the bunches by hand. They should be freshly gathered and without being unnecessarily bruised or damaged. The pericarp of the newly gathered fruits contains about 66 per cent. of oil.

The oil varies from a light yellow to a dark red colour and is sometimes of a buttery or tallow like consistency. The oil is a fat having a sweetish taste and an odour resembling that of violets which persists even after long contact with air at high temperature. the fatty acids contained in the oil are chiefly palmitic and oleic.

From the soap manufacturers' point of view, palm oil makes an excellent soap stock yielding a pale soap of a firm texture and compact body.

The oil melts at 27° to 42.5°C according to the age and origin of the oil and solidifies at 30° to 40°C.

SOYA BEAN.

Soya bean is obtained from plants botanically named as *Glycine hispida*. The soya plant is said to be the most important leguminous plant in the Chinese Empire and Japan and the produce is put to a great variety of uses. The plant also thrives in Burma.

Though the chief value of the soya plant, lies in the bean itself, being used as food for man and domestic animals, an oil is drawn from the beans. The oil is used largely for making salads and sauces, and is also mixed with flour in the manufacture of cakes. The expressed meal is made into bean-cakes.

The soya bean contains about 18 per cent. of oil. Although introduced upon the European market only comparatively recently, the oil has found wide and varied application in the manufacture of boiled oils and soap. It contains about 80 per cent. of the glycerides of liquid fatty acids, the bulk of which are oleic and linolic, while the solid acids appear to be palmitic.

NEEM OIL.

Margosa oil, commonly known as Neem oil, is the oil obtained from the seed of *Melia Azadirachta*, a large evergreen tree growing wild throughout the greater part of the Indian Peninsula. Certain medicinal properties are attributed to the oil.

Neem oil yields a fairly hard soap, and is of much value, since most of cheap soap-stocks available from vegetable sources in India are of the soft kind. The soap from neem oil is almost as hard as the mahua soap.

CLEARING AND STORING OIL SEEDS.

The storage of the oil seeds requires considerable attention. When fresh, the seed should be spread out upon the floor of the storehouse in piles not more than 3 inches high; otherwise, it becomes readily musty and mouldy. There should be sufficient ventilation to constantly renew the air impregnated with moisture, without exposing the seed to the action of wind and weather. For rapid drying the piles should be turned over with a shovel twice a day. When dried up the

seed may be piled up 1 foot high in summer and 2 feet high in winter; the piles must, however, be turned up with the shovel at least once or twice a week, because the seed re-absorbs moisture from the air, and is again exposed to the danger of becoming mouldy. By absorption of such moisture from the air the seed becomes heated in the pile, commences to get sticky and cakes together. Spontaneous heating of the seed exerts considerable influence upon the oil content of the seed. The oil is inferior in quality and the yield much smaller.

If heating in the pile and caking together has progressed to some extent, turning over the piles with the shovel is of no avail. The only remedy in this case is to pass the seed through a fan and then immediately express the oil so as to utilise, besides the inferior quality of the oil, the oil-cakes for feed.

Great precaution is therefore needed in storing and selecting the seeds. Unless the seeds are preserved in cool and dry places, there is every chance of the seed getting deteriorated in quality and failing to produce the best quality of oil. The cotton seed in special is a very perishable and unstable produce, for even the pressure of the mass, if stored in bulk, especially if any portion of it has been trampled on or crushed, suffices to cause heating and a rapid fermentation which destroys the kernel entirely or renders it incapable of producing oil and meal of superior quality. No plan has yet been devised to preserve them in large quantities and when rapid handling is required. Mention should also be made here of the fact that the seeds from the early part of the season do not keep as well as those of the second and third pickings.

CHAPTER III.

RAW MATERIALS.

BESIDES oil seeds which play an all-important part in the making of oils, a number of chemicals are called in requisition, though in smaller quantities, for the purposes of refining, bleaching or deodorising the oil. The most important of them are caustic soda, sodium carbonate, fuller's earth, sulphuric acid, sodium silicate, etc. etc. A short description of the most important of them and their treatment follows:—

CAUSTIC SODA.

Caustic soda comes into commerce in four forms: (1) sticks, (2) flakes like scale of fishes, (3) blocks in casks; (4) solution. The caustic sticks are however rarely used in soap making on account of their high prices. Caustic liquors are not also taken into credit for containing too much impurities. Flakes and blocks are in use.

Commercial caustic soda is a creamy or white mass, having a slightly fibrous structure. It is very hygroscopic, readily absorbing water from the air and passes into a highly caustic liquor. It also readily absorbs carbonic acid from the air, passing into carbonate. Hence it is not desirable that caustic soda should be exposed too much to the air.

Caustic soda is sold in the market in a variety of grades, each grade containing a definite percentage of caustic soda.

Grade	per cent of caustic soda
60°	77·42
70°	90·32
72°	92·90
74°	95·48
76°	98·06
77°	99·35
77·5°	100·00

The figures indicating the grade have a significance. The degrees represent the percentage of sodium oxide present in the alkali. The highest grade, containing as it does more available caustic soda and less impurities, is much more advantageous to use. For example, 77·5° caustic soda means that 77·5 parts by weight of sodium oxide are present in 100 parts of the caustic soda. And since from the molecular weight of the caustic soda it appears that 80 parts of the soda contain 62 parts of sodium oxide, 77·5 parts of sodium oxide must be present in 100 parts of the caustic. It therefore comes to this that cent per cent pure caustic soda is designated as 77·5°, while a caustic soda of 90·32 per cent purity will contain 70 parts by weight of sodium oxide and will consequently be designated commercially as 70°.

MAKING CAUSTIC LYE.

Lyes of caustic soda are prepared by dissolving in water the solid caustic hydroxides. The commercial caustic soda is usually supplied in large drums which require to be broken open before the caustic, these contain, can be dissolved. This caustic is dissolved in iron tanks with a suitable quantity of water. The correct way of doing this is to suspend the solid caustic at the top of the tank just underneath the surface of

the water used to dissolve it; then the lye as it is formed, being heavier than the surrounding water, sinks to the bottom, so that the solid caustic, by reason of the currents thus set up, is always coming in contact with fresh water or unsaturated lye, and consequently soon becomes dissolved. This may be carried out by placing a perforated iron plate just under the surface of the water or liquor in the tanks. The solid caustic may be broken out of the drums and thrown into the iron tank for solution.

Caustic soda lyes should not be kept too long exposed to the atmosphere, as they tend to absorb carbonic acid and pass into carbonate of soda, the alkaline or soap-making strength being thereby reduced. It is better to prepare the lye freshly whenever required. Soda lyes of any strength may be made from the solid caustic. Strength of the lyes in terms of actual caustic contents, however, varies considerably with the grade of caustic taken.

CONCENTRATION OF THE LYE.

•• The concentration of the lye required for saponification varies with the nature of the oil to be treated. Strong and weak solutions are both to be made. The strength can either be expressed by mentioning the quantities of the water and the soda in full or by giving the specific gravity or degrees as recorded either by a Twaddle's or a Beaume's hydrometer. In the first case there is no difficulty in preparing the solution but the preparation of a solution of a definite specific gravity from the waste lye becomes a difficult operation. In such cases the specific gravity of the waste liquor is to be first determined and then the further quantity to be added is to be calculated out. Considered from all points of view it is easier and more con-

venient to use Twaddle's or Beaume's hydrometer. In preparing the lye of a given strength the caustic is added to water little at a time, the hydrometer is put into solution and the mark to which it sinks gives the strength of the lye. If greater strength is to be attained, more soda is to be added till the correct reading is obtained. If the strength is already too high, the lye is to be diluted with more water.

QUANTITY OF SODA TO BE ADDED.

The approximate quantity of caustic soda of 77° degree to be added to 100 parts of water to get lyes of different strengths follow:—

	Water	Caustic Soda (77°)
5°Be	100 parts	3·56 parts.
10°Be	100 "	7·4 "
15°Be	100 "	11·45 "
20°Be	100 "	16·78 "
25°Be	100 "	22·84 "
27°Be	100 "	26·36 "
28°Be	100 "	27·58 "
30°Be	100 "	31·05 "
32°Be	100 "	34·66 "
33°Be	100 "	36·68 "
35°Be	100 "	41·16 "
36°Be	100 "	43·33 "
37°Be	100 "	45·91 "
38°Be	100 "	48·38 "
40°Be	100 "	54·17 "
42°Be	100 "	60·44 "
44°Be	100 "	67·38 "
45°Be	100 "	69·64 "

CAUSTIC POTASH.

• Caustic potash possesses chemical properties very similar to those of caustic soda. Only it is much stronger in chemical action than the latter in every respect. Caustic potash dissolves readily in water forming a lye with considerable evolution of heat. It is hygroscopic and readily absorbs carbon dioxide from the air and is converted into potassium carbonate. Hence it is of the utmost moment to the manufacturers that the caustic lye should be as little exposed to the air as possible.

SODIUM CARBONATE.

Next in importance is the carbonate of soda. It occurs in the market in five distinct forms, viz. soda ash, refined alkali, soda crystals (occurring in large crystals), crystal soda (occurring in small crystals) and bicarbonate of soda. Soda ash is available in two forms, viz., caustic soda ash and carbonate ash and possesses varying degrees of strength known as 48 degrees, 50 degrees, 52 degrees, up to 58 degrees. The degrees refer to the amount of alkali present in terms of sodium oxide but expressed as English degrees.

Soda ash 48° sometimes called caustic soda ash often contains besides carbonate of soda, 4 per cent caustic soda (sodium hydroxide) and 10 per cent salt (sodium chloride) together with water and impurities.

Carbonate of soda or soda ash 58°, also termed "light ash" and refined alkali is commercially pure sodium carbonate containing about 0.5 per cent. salt. The 58° represents the English degrees and corresponds to 99 per cent sodium carbonate. It is better to use 58° stuff than the 48° one.

Sodium carbonate is also available in crystal forms and is then known as soda crystal. It contains less impurities than soda ash.

POTASH CARBONATE.

Potash carbonate is also used to a little extent in removing the fatty acids from the oil. Its properties are analogous to those of sodium carbonate.

The standard for refined carbonate of potash is 90-92 per cent of actual potassium carbonate present, although it can be obtained tested 95-98 per cent.

SODIUM SILICATE

Sodium silicate is brittle, breaking with conchoidal fracture and resembles glass. Liquid sodium silicate is a viscous substance having a specific gravity of 1.50—1.54 which is equivalent to 50°Be. It is alkaline in character and is used for refining coconut oil. It is only sparingly soluble in cold water and settles down in the bottom in that case. The silicate, however, gets dissolved in hot water. The strength of the silicate solution should not exceed 40°Be. As a general rule by mixing equal parts of water and silicate a strength equal to 40°Be is obtained. To get lesser strengths the proportion of water should be increased.

FULLER'S EARTH.

Fuller's earth is a soft, unctuous, friable, greenish or yellowish grey species of clay containing 53 per cent. of silica, 10 per cent. of alumina, and 9 per cent. of the oxide of iron. It is extensively used in the bleaching of oils as it has the property of carrying down with it the colouring matters present in the oil.

ANIMAL CHARCOAL.

Animal charcoal is another refining agent and is largely put to use by the small refiners. Before it can be used, the charcoal should be broken into pieces and

heated. It is in the heated condition that animal charcoal gives the best results.

Animal charcoal may be made at home. To do this, good pieces of bones are thoroughly cleaned by boiling in water. The bones are then dried and broken into smaller pieces which are next charred in a closed retort out of contact with air. The charring should be done in such a way that all parts of the vessel up to the neck should receive, as far as practicable, the same amount of heat. The charring is complete when no further fumes are given off on opening the lid of the heating vessel. The charcoal should now be allowed to cool, with the mouth of the vessel still covered up. Then it should be taken out and powdered. The powdered mass is next boiled with hydrochloric acid and washed with water until the washings are perfectly colourless. The washed charcoal powder is then dried, care being taken to protect it from contamination with dirt and dust. It is then stored up for use. Bone charcoal is also available in the market ready for the refining of oil.

STEAM.

Steam is one of the most important agents which bleach oil. All up-to-date oil mills should therefore have arrangements for the generation of steam.

KIESELGUHR.

Kieselguhr, which is largely composed of diatomaceous, hollow particles of microscopic size, has the property of absorbing oil-suspended matters and is therefore used to filter and refine oils. Both the crude and finely ground calcined variety may be used. The best kieselguhr, however, is pure white and free from iron impurities and has a filtering capacity five times as great as that of an ordinary crude or calcined earth.

It also yields a fairly refined oil with a saving in filtering cloth, labour costs, etc.

OTHER MATERIALS.

The other reagents for the bleaching of oil are potassium bichromate, magnesia, salt, lime water, sulphuric acid, calcium chloride, etc. These are available in the market ready made and as they do not require any previous treatment, no description is necessary in their case.

CHAPTER IV.

OIL PRESSES.

PRESSING system has been known and employed from the remote ages for the expression of oil and has now practically resolved itself into the use of three system, the Ghani, the Plate (or Anglo-American system), and the Cage system.

COUNTRY GHANI.

In India country *ghanis* are in use from time immemorial for the expression of oil from seeds and even at the present moment they are being used throughout the country.

The main parts of the *ghani* are as follows:—

- (1) The mortar including the cavity and the drain.
- (2) The stirrer.
- (3) The pit.
- (4) The pestle.
- (5) The curved wood.
- (6) The weight beam.
- (7) The beam post.
- (8) The yoke.

THE MORTAR.

The mortar is carved out of a thick stump of tree in the shape of a bowl. The lower part of it is buried underground so that the mortar does not give way any side under pressure. The wood generally used for

mortar is that from Tamarind, Neem and Sireesh: occasionally 'Rayan,' 'Mahowa,' 'Arjan' and 'Babul' are also used. But there is possibility of these being cracked. Tamarind wood is used in most parts of India. Neem is popular in Gujarat, Khandesh and Bihar. 'Sireesh' is common in Central Provinces.

The height above the ground should be about $2\frac{1}{2}$ feet, and in order that it may not tumble over it should be buried underground about 3 feet. Thus in all, the total length comes to about $5\frac{1}{2}$ feet. The wood should be straight as far as possible. Sometimes it is difficult to secure such large wood and to meet that difficulty extra pegs or a cross seat may be attached at the bottom.

The diameter of the mortar should be such as would leave its walls strong after the hollow space for pit is scooped out of it. Also there should be sufficient space to contain the required quantity of seeds. It should therefore be at least 2 feet. However, if the girth is a little less, an iron belt can be fixed round it for strength and extra pieces of wood can be attached for space.

The cavity is about 18 inches deep, 14 inches broad at the top, 12 inches in the middle and 13 inches at the bottom. After the cavity is scooped out immediately above it, a circular margin in the mortar about $1\frac{1}{2}$ " broad and about $1\frac{1}{2}$ " deep should be made in which the stirrer moves to push the seeds into the pit. Also the top of the mortar should slope towards the cavity by about an inch.

The cavity should be enlarged if the cavity per charge is to be increased. If the cavity is broader, then it can be fitted with thicker planks which will last longer.

THE PIT.

The pit is that part of the press where the pestle presses the seeds. The construction of the pit should be such that the pestle should be brought into such relationship to the pit as to cause the seeds to be well crushed and the oil to be pressed out effectively. To bring about this result, the first condition is that the pestle should revolve in the pit at as great slant as possible, because the pressure increases with the slant. This pressure can be represented by the distance between two perpendicular lines from both ends of the pestle. The distance between the lines varies with the slant, therefore the pressure increases as this distance increases. If the pestle revolves nearly upright, then the pressure is not on the side of the pit but at the bottom. The slant brings pressure to bear on the sides.

If then the pestle is to be kept at a slant, the sides of the pit should also be made sloping. Its slant also is automatically limited. One limit is that the curved wood over which the extra load hangs should not fall down. Another limit is that the circuit of the bullock should not be unnecessarily increased, simply due to the slant. And the third limit is the girth of the wood of the mortar, for the pit can be enlarged only in proportion to the girth of the wood.

It is also necessary to slope the bottom of the pit from the sides towards the centre. If this is not done, the pestle will leave a space as it slants, and the result will be that the cake will block the mouth of the drain. Thus the pestle and the bottom should fit exactly even when the pestle slants.

If the sides of the pit are smooth, the seeds slip and do not get pressed soon. This can be checked by making grooves on the sides. It is convenient to

make the grooves straight because the slanting grooves are often broken by the crow-bar used in digging out the cake. In the case of grooves which slope in a direction opposite to the direction of the movement of the pestle the cake is prevented from coming to the top.

To enlarge or decrease the capacity per charge the depth of the pit should be enlarged and decreased. But in doing that the capacity of the bullock should be taken into consideration. For an ordinary single bullock, a charge of about 20 lbs. is convenient.

The wood of the planks that make up the pit is generally "Babul." In the C. P. sometimes 'Kusum' is also used. Both the woods are strong and non-fibrous. The pit gets worn out every 15 to 18 months.

THE DRAIN.

The drain is to be bored from the bottom of the pit on a side to come out at the other end near the ground. If the wood is defective then a zinc pipe should be fixed to make it proof against leakage and wear. Below the mouth of the pipe a tin drain or a piece of wood with cavity in the middle is tightly attached to the press to form a lip which will facilitate the oil to run through it into a vessel, instead of running down the sides. The drain should not come out much below the ground level, for then the pit for the receptacle for oil will have to be rather deep. When the pit is deep, it is difficult to take out the receptacle when it is full of oil as well as to thrust the rod to clear the drain hole. As it is best to have the drain straight in order to clean it off and on with a rod and a good slope is necessary for the oil to drain out quickly, it will be found that the drain will have to have its outlet fairly deep. Moreover, as this drain

has to be bored from the inside after the cavity for the pit is made in order that the hole for the drain is exactly where it is needed in the pit, it will be found that the wall of the cavity will come in the way of the borer if it is sought to bore too slantingly.

THE PESTLE.

The pestle is meant to fit the mortar. Best wood for its construction should be non-fibrous. 'Babul' or 'Kusum' is such wood, but 'Babul' is more commonly used. Sometimes 'Bhera' wood is used, but it is not used in the replaceable parts. In selecting the wood for the pestle, one of the considerations should be that after it is worn out, it should be fit to be used in the making of the replaceable parts. Otherwise, the wood soaked and seasoned with oil goes waste every time.

If the pestle wears out and becomes thin for the worn out pit, it need not be thrown away, but can be used for a new pit which is proportionately narrow. If the pestle is long enough, its ends can be reversed to take each other's place, but it is difficult thus to economise in a short pestle.

The pestle is divided into two parts, the top edge of the pit becoming its fulcrum. The longer the distance from the fulcrum to the top end of the pestle, the greater the pressure brought to bear on the seeds, without bringing any additional burden on the bullock. From this point of view it is convenient to keep the pestle about 10 feet long, and in order that it may not be too heavy, it should be kept as thin as possible, say about six inches in diameter.

While revolving, the pestle should move uniformly without jerks, otherwise there is danger of the curved wood tumbling down.

For the top end of the pestle there is no particular shape or size to be kept in mind except the tapering point. The cut in the pestle at the lower end should be an inch above the fulcrum point. If the cut touches the pit, it will press the cake which will stick outside the pit and will have to be removed from there all the time. Also, if the cut rests on the top surface of the pit, the pestle will not revolve on the wall but slip off.

To make the lower end of the pestle which revolves in the pit of the right size, it must be seen that not much space is left between it and the side of the pit. It should of course revolve touching the fulcrum. Near the neck of the pit a rounded hollow about $\frac{1}{2}$ inch deep $1\frac{1}{2}$ inch broad extending from about 2 inches above the part of the pestle touching the neck of the pit to about 2 inches below is made in the pestle to allow the oil to run down.

THE STIRRER.

The stirrer is a device to brush the seeds in the pit and moves over the pit in advance of the pestle. It is hung from a nail in the upright post, where it is tied to the post. An extra load of about ten seers is hung over it to give it force to push the seeds.

The end of the stirrer which touches the wall of the mortar should be curved in the same way as the nail in order that it may move smoothly. The front part that pushes the seeds should be broad enough to extend a little over the pit and should be about 2 inches high to prevent the seeds going over it.

THE CURVED WOOD.

The load of the weight beam that brings the pressure to bear on the pestle is hung on a curved wood which moves resting on the pestle. As that wood moves

with the pestle its curve is nearly at right angles. Since it has to carry a big load the wood must be strong. Thick wood of any inferior kind will do; but if it wears out soon, it will have to be replaced every now, and then. Hence "Babul" wood is preferable.

THE WEIGHT BEAM.

The strain that the bullock has to bear depends mainly on the contrivance of the weight beam. Length of the beam should be sufficient to allow the bullock to drag it conveniently, that is, the bullock should be able to turn easily and the ropes round it should not rub against its body. Thus calculated, the beam should be about 5 feet long for the bullock.

PLACE OF THE UPRIGHT POST IN THE BEAM.

To make the beam move lightly it should be made to rest just on the mortar while moving. The beam hanging from the post will rest on the mortar nearly at right angles. The post should be exactly where it will balance the beam. The measure of this distance depends upon the length of the pestle. If the pestle is short, the beam will be balanced by keeping the post nearer the mortar; while if the pestle is long it will be necessary to fix the post at a greater distance from the mortar. The position of the post is accordingly round about the centre of the beam, which can be adjusted by making a long hole for the post, and inserting pegs in it either at one end or the other, and by changing the angle of the post in the beam.

The beam can be made to move easily if it slopes towards the bullock. This is done by making the post slant in the opposite direction and raising the surface of the outer end of the beam by fixing a high plank. The stones should be placed on the beam from this plank.

YOKING ARRANGEMENT.

It is a simple device consisting of ropes and sticks and a curved yoke broad enough for the bullock's neck. The combination of ropes and sticks passes on two sides of the bullock and is joined at one end to the yoke and at the other to the weigh-beam. A rope is also passed under the bullock's body connecting the two ropes. There will be less chances of hurting the bullock if a cushion were placed under the yoke and if leather were used instead of ropes.

As the pestle of the machine revolves the material under treatment is pressed between it and the mortar until the oil flows freely through the outlet to which a gutter is attached and may be collected in a receiver below. After being sufficiently pressed, the exhausted material rises to the top of the bowl and is removed, and fresh material is put instead. Owing to the low outturn, and higher working costs it is somewhat less economical as an oil producer.

The oil produced in the *ghani* may be regarded as better than oil produced by modern machinery. The *ghani* oil being cold-drawn retains its characteristic aroma and is suited to edible purposes but the machine oil generally lacks this property. But in spite of these advantages the outturn of country *ghani* is too low and the cost of repairing the machinery parts is so great that this system is getting out-of-date in India and abroad.

ROTARY GHANI.

The principle of country *ghani* has now been applied with certain modifications to the rotary *ghani* system in many oil mills in India. Its simplicity and low cost enables it to be run in a small way, and in dealing with most oil seeds it is surprisingly efficient.

In rotary *ghanis*, both mortar and pestle are made of iron and are capable of rotation in opposite direction. This hastens the operation of the expression of the oil. Rapid rotation also generates heat to some extent which also facilitates the expression of the oil. Batteries of ten such *ghanis* are generally mounted on a substantial framework and can be driven by a crude oil engine. But owing to the high cost of repairing, these *ghanis* are gradually being replaced by hydraulic presses.

ANGLO-AMERICAN (PLATE) PRESSES.

The Plate or Anglo-American system is usually employed for the treatment of all seeds requiring one pressing only. A combination of that plate and cage systems is used for all oil seeds requiring two pressings, or for the production of two qualities of oil, edible oil from the first pressing, usually cold-drawn, and second quality oil from the second pressing, usually drawn hot.

In Anglo-American Oil Presses the crushed seed is enclosed in press cloths or wrappers and placed between the open plates of the press, the press cloth serving the purpose of retaining the solid matter whilst allowing the oil to escape.

These presses are of great importance in factory work on account of the high pressure they yield with a small consumption of power.

The press consists of a cast iron head and bottom, united by four forged steel columns having buttress threaded nuts at each end. A cast-steel cylinder rests within the bottom casting, and a hollow cast-iron supports a cast-iron table or head. The bottom casting is flanged all round to form a tray in which the expressed oil is caught. Between the top and bottom

castings steel plates are arranged horizontally. These plates provide spaces for 16 cakes, each space, when the plates are fully dropped, being $2\frac{1}{2}$ inch in depth. Each plate is hung from the one above by means of four oval mild steel links slipped over square-headed studs screened into the plate edges, the top-most plate being hung similarly from the top casting. To the inner-side a flat square-edged runner or guide is pinned. This method of supporting the plates secures the required condition, namely, that the plates, when pressed upwards should close together without friction or at least without cumulative frictional resistance. The corrugations on the press plates as well as the longitudinal ridges which are raised on the plate, are intended, as far as possible to prevent the meal from spreading when the pressure is applied.

The press gives a greatly increased pressure and capacity, reduces the weight of plant used in working a given quantity of seed, as well as the space taken up by it. The standard size of press has a 16 in. ram and makes 16 cakes taking a total charge of, say, 220 lbs. crushed Bombay linseed. In larger mills Anglo-American Presses are worked in sets, or batteries, a set of presses usually comprising four, but sometimes five, or as many as six presses.

HYDRAULIC CAGE PRESS.

Cage or Perforated Box Presses offer an alternative method of treating various oil seeds by pressure, and for certain seeds and nuts, more especially those containing a large percentage of oil, cage presses offer distinct advantages over the Anglo-American presses.

In milling with Anglo-American presses it will readily be seen that where seeds contain a high percentage of oil, the hydraulic force exerted against the press cloth may be considerable before the oil has time

to escape, and the natural result is a large number of burst wrappers. A good deal can be done to avoid this by the care that is used in putting the pressure on the press, but in the cage presses, wrappers are not required, as the perforated extracting box serves the purpose of retaining the solid residue, and allowing the oil to escape.

When the seeds contain much oil, as in the case of copra and castor seeds, the cage or clodding presses are often used for the first expression whilst the plate press as indicated above is used for the second and third expression.

The cage press consists of a cylinder of cast-steel fitted with a cast iron piston or ram capable of exerting a working pressure of 3 tons per square inch. A massive cast iron block is supported at the top of four iron rails on which runs a plunger actuating by a rack and pinion. The press is provided with automatic stops for holding down the cage when extracting the cakes. There is a large oil receiving dish fitted with stuffing box and wiper to prevent any pressure fluid adhering to the ram from mixing with the expressed oil. The cage is constructed of vertical bars firmly bound together by a sufficient number of weldless forged steel rings to withstand the bursting pressure. The ram is forced out of the cylinder by the hydrostatic pressure of a liquid pumped into the cylinder in a small stream and thereby exerting great force on the contents of the cage.

Cage press of another type is provided with a cast iron head, four forged-steel columns with buttress threads, a cast-steel cylinder and a cast-iron ram. The bottom of the press is formed solidly with the cylinder, and is therefore of cast steel. A circular cast-iron oil tray, provided on its underside with four horses through which the columns pass, rests on top

of the cylinder casting. The ram rises through a gland at the centre of this tray. Just above the tray four split muffs are bolted round the columns to provide stops. Thereon the cage may rest in its lowest position.

HYDRAULIC PUMP.

The press pump consists of two pistons of different diametres, the larger stopping automatically at about twenty inches of pressure, whilst the smaller continues working until the desired pressure is obtained. The pressure from the pump is evenly transmitted, through the liquid and the connecting valve, to the liquid in the cylinder containing the ram. This exerts on the latter the same effect per unit of surface as on the same unit of the pump piston. The pumps are constructed in such a way that any one of the rams may be put out of action when it is necessary to change ram leather.

EXPELLER.

The use of expeller is the latest development in oil industry. Here the operation can be carried on continuously. The pressing of the seed is performed in a pressing box or cage and consists of a number of bars of special hard steel. A shaft carrying a series of steel screws, revolves in this box. These are so arranged as to produce a gradually increasing pressure, the amount of pressure being regulated by a cone. The oil flows through the spaces between the bars, and the pressed cake is discharged at the end of the pressing box. Seeds can also be pressed cold in an expeller without crushing but of course the best results are obtained by rolling the seed and heating the meal.

CHAPTER V.

MACHINERIES.

IN milling oil with country *ghanies*, the indigenous form of the oil mill, no auxiliary machines are required. But when oil milling is taken up on an improved scale, up-to-date machineries are to be installed to get an increased outturn.

Most important of modern machines are no doubt the Anglo-American plate press, the cage press or the expeller. But large number of auxiliary machines are required to treat the seed before pressing and the oil cake after the extraction of the oil. These include the seed cleaning machines, disintegrators, decorticators, crushing rollers, meal heating kettles, cake paring machines, etc.

The factories which would like to undertake bleaching and deodorising should be furnished with a number of appliances such as filter presses, percolators, specially designed kettles, vacuum pans, etc., etc.

A short description of the principal machineries in use is given below and the purposes they serve are also noted. The machineries and accessories employed in connection with the bleaching of the oil are dealt with in a subsequent chapter.

SEED CLEANING MACHINES.

The seed cleaning machine is intended to remove dirt, dust, sticks, etc. from the seed. The machine possesses an inclined revolving cylinder covered with woven wire having meshes varying according to the size and nature of the seed to be operated upon. The

impurities are removed by sifting. These cleaners are also furnished with fans which blow off the dirt, straw, and other light matter not removed by screening.

DISINTEGRATORS.

The disintegrators are specially designed machines to break the oil seeds into smaller pieces to make them easily pressable in the mill. The machine differs in construction according to the nature of the seed to be crushed. Essentially the disintegrators are made with one, two or three pair of horizontal rollers, which are either plain or grooved, depending upon the class of seeds to be treated. They are particularly necessary for such seeds as copra, mahua, castor, and groundnuts which will not bear heavy rolling, until freed from some of their oil content.

DECORTICATORS.

Decorticators are meant to remove outer coating or shells of the oil seeds, before expression. The machines work in such a way that the kernel and husk are separated. Special machines have been constructed to decorticate castor, cotton and groundnut seeds. The process depends on cracking the brittle seed-coats between rolls so as to exert a cracking pressure rather than a crushing and mangling one. The broken seeds are then dropped on a shaking screen which serves to shake the kernels out of the adhering seed coats and otherwise loosens up the mass. As the charge falls over the end of the shaker, a current of air blows out the seed coats while the kernels are collected into a hopper below.

SEED CRUSHING ROLLS.

The crushing rollers are meant to crush the seeds prior to being pressed. Whatever be the original form

of the material, it is delivered from the preparatory machinery in the form of "meal." The rollers are made of special chilled iron steel cylinders which, on account of an extreme hardness and greater durability, are much preferable to that of ordinary cast-iron. Each roller is fitted with a mild steel spindle, forced in by hydraulic pressure and securely keyed. A series of four or five such rollers are mounted in vertical order in a cast-iron framework of massive construction. This has vertical slots in which the bearings of the upper rollers are free to slide. The seeds are fed by a hopper at the top and pass in succession between the first and second roller in the series, then between the second and third, and so on until they come out at the lowest, sufficiently bruised, crushed and ground.

MEAL KETTLES.

When the oil is to be expressed hot, as is usually the case, the meal has to be heated. The heating of the meal is commonly conducted in a steam "kettle" and is, of course carried out immediately before the pressing takes place, so that the material when placed in the press may still be hot.

The heating of the meal greatly facilitates the expression of the oil from it, for it results in the rupturing of the minute vessels or sacks in which the oil is naturally contained within the meal. The heating proper of the meal is effected usually by means of a steam jacket surrounding the kettle.

There are various types of heating kettles. A standard form of heating kettle consists of a double steam kettle, one pan being placed above the other—each steam-jacketed and provided with mechanical stirrers. The meal is first heated for 10 or 15 minutes in the upper pan closed over with a sheet iron cover. After this a slide in the bottom of the pan is opened

and the charge is shot down into the lower pan, where it is raised to the full heat, while the upper pan is recharged and worked up. In some machines there are arrangements for continuous heating.

A typical meal-heating kettle is a cylindrical iron vessel jacketed round its side and bottom for heating steam at a pressure of about 75 lbs. and containing power-driven stirring gear. The steam jacket round the side is covered with a layer of non-conducting material, enclosed with in a sheet metal casing. The top of the kettle is open, except for the cast iron bridge, which spans it and carries the driving gear. The bottom of the kettle with its steam jacket is made readily detachable from the rest for renewal purposes, as this part is that which is most subjected to wear. The thorough agitation of the meal in the kettle is necessary, not only to attain uniform heating, but also to prevent its becoming discoloured.

RECEIVING PANS.

When the meal is to be pressed cold a heating kettle, of course, is not required. It is convenient, however, to provide a "receiving pan" for the meal, from which the moulding machines may draw their supply. The kettle itself acts as a receiving pan when hot pressing is being followed, and with the steam shut off from the jackets it may still so serve when cold pressing is adopted.

MEAL-MOULDING MACHINES.

The object of the moulding machine is to press the meal into the form of a cake, so as to facilitate the filling of the main presses. The moulding pressure employed must not exceed that at which oil will commence to flow from the meal. The moulding machine must be reliable and quick in its action. As each cake

is formed in it, it is taken away to the press and a succeeding cake moulded.

There are various forms of moulding machines in the market. A hydraulic meal moulding machine consists of a massive cast-iron base, on which is bolted the pressing cylinder, the ram carrying the pressing table. The fixed head is carried on four steel rods and cast iron distance pieces. The movable head is hinged to a strong cast-iron bracket at the back and locked. It is balanced by two powerful springs, provided with suitable adjustment to regulate the tension. The mould frame is made of carefully selected hard wood, lined inside with zinc and on the top with sheet steel. It is generally arranged close beside the kettle so that the strickling box filled with meal may be readily drawn over on to it. The strickling box leaving the supporting board of the kettle passes on to the hard wood frame and is guided thereon by the upstanding edges of the block. The block is counterbalanced and is hinged to turn upwards and backwards.

CAKE PARING MACHINES. •

Cake trimming machines form an important factor in the economy of oil mills. They are made in a variety of forms. A typical cake paring machine comprises two knives worked by power along the edges of a slot at the centre of its table. The oily parings fall into the slot, when they are caught in a trough and are broken up and moved forward to the spout by a series of steel conveyor knives mounted on a power-driven shaft within the trough.

FILTER PRESS.

The filter press is used in the oil industry for effecting the separation of solids from the oil. It consists primarily of a series of cast-iron plates formed

with a lug at each side; these lugs support the plates on a pair of steel rods extending between the two fixed ends of the press. The edges of each plate is raised up so that when two adjacent plates are brought together the dished centres form a chamber between them. Through the centre of each plate there is a circular feed hole for the oil. Each plate is provided with two filtering cloths, which with central holes are united round the edges of these holes by means of a short cylinder. The cloth on one side can readily be rolled up, slipped through the central hole in the plate and spread out flat on the other side. The two cloths to facilitate the assembly of the plates are then held at their upper edges by means of clips passing on to a rib formed across the top of the plate. In this way all the plates, thus clothed, have been assembled in the frame work of the press. By proper adjustment all openings between the plates are closed.

In filtering the oil to be refined is made to pass, under pressure, through the series of plates and is received below in a receiving vessel.

CHAPTER VI.

PRINCIPLES OF OIL EXPRESSION.

THE oil of the seeds nearly always occur embedded in cells of the plant tissue, and some process is therefore necessary to remove the oil from the plant in order to prepare it for use. In the earliest times the few recognised vegetable oils were prepared by hand pressure, and later by crude wooden presses but at the present time oil may be extracted by hydraulic pressure, by heat, by grinding or by the use of volatile solvents. The oils used for technical purposes do not require particular care in their preparation, but where good colour and flavour are essential, the greatest care has to be taken from the very gathering of the seeds in all stages.

The general methods of treating the seeds for the expression of the oil require careful attention, and wherever possible the existing methods should be improved upon for ensuring a larger yield of oil of superior quality.

STORING THE SEEDS.

In some cases the oil is expressed from the seeds immediately these are gathered, but where this is not the case great care must be taken in the transportation and storage of the seeds so that they are kept free from moisture and also from light. The seeds should also be loosely packed so that no heating action takes place. The flavour of the oil may be seriously impaired by fermentation or other changes occurring in the seed during storage.

PRELIMINARY TREATMENT.

The seeds as reaching the mill often contain a good deal of impurities, such as dust, sand and various other impurities. If these are not removed, the wear and tear of the machinery is increased so much that sometimes the machinery parts are broken. Moreover the presence of foreign impurities which go to the cake lower its nutritious value, for the cakes may possess a disagreeable after-flavour. Again, the presence of sand or dirt tends to wear out the machinery, in addition to injuring the proportion of non-nutritious material in the oil and cake. Moreover the presence of these foreign bodies will also coagulate with a thin film of oil and it is impossible to recover it by pressure; hence the yield of oil from a given quantity of seeds is comparatively reduced.

The process of milling the seed involves broadly the following heads:—

(1) Cleaning, (2) Decorticating, (3) Grinding, (4) Heating, (5) Moulding, (6) Pressing, (7) Paring, (8) Recovery of oil from oil parings, (9) Refining. ..

CLEANING.

Before the actual business of expressing the oil is commenced, the seed is cleared by the use of screens. a screen of fine mesh being used to remove particles smaller than the seeds, and one having a mesh slightly larger than the seeds which will allow them to pass through, whilst retaining larger impurities. It is also very usual to pass the seeds over magnets which remove any particles of iron which would be deliterious to the machines subsequently used. It should be noted that oils of the finest flavour are produced by crushing the cleanest seeds only.

DECORTICATING.

The oil seeds are generally enclosed in a shell or husk, which is to be removed if the best quality oil is to be produced. The groundnut kernel, for example, is surrounded by a shell which is light and does not contain any oil. The cotton seed of commerce again has an outer coating of fuzz or lint. The mustard seed, castor and linseed all have an outer coating. In some cases the outer coating of the seed is removed before the oil is expressed; this process is known as decortication. The shells are removed by means of revolving knives which are so adjusted that they cut the shell without injuring the kernels. The shells may then be removed by a strong air current. It is to be noticed that if the shell or outer coating is not thrown away before pressing, the pressing capacity of the oil is reduced and at the same time the oil drawn is of darker complexion and inferior in quality.

In case of oil seeds of irregular sizes it is very difficult to make a perfect separation of hulls from kernels by the mechanical decortication, because the smaller ones readily drop between the rolls unaffected while the larger ones are crushed. This requires a grading of the seeds which of course can readily be done by hand.

DISINTEGRATING.

In the case of copra, mohua and groundnut, the oil bearing portion is too big to be efficiently handled at once. They will not bear heavy rolling until freed from some of their oil content. The size of the seed is therefore to be reduced without actually milling it. The cleaned, decorticated and disintegrated seed is then to be crushed as a preliminary step to milling.

GRINDING.

The thorough crushing and breaking of the oil cells of seeds and nuts (e.g. copra, cottonseed, etc.) is of vital importance in obtaining the best results as regards yield of oils. For this purpose use is made of seed crushing rolls.

The screened seed passes into the hopper in the usual manner, and is distributed to the crushing-rolls by a fluted-feed-roll placed at the bottom of the hopper. When the seed passes the feed-roll, it falls on a guide plate that carries it between the first and second roll. After passing between these rolls and being partly crushed, it falls on a guide-plate on the other side, which carries it back between the second and third rolls, where it is crushed more fully. It then falls on another guide plate which carries it between the third and fourth rolls, where it is ground more fully; then it falls on a fourth guide plate, and is conveyed between the fourth and fifth rolls to receive the finishing touch.

COOKING THE MEAL.

Oils of the finest flavour are produced by crushing the cleanest seed and subjecting it to hydraulic pressure in the cold, but for inferior and non-edible oils a much larger yield is obtained by heating the crushed seed in a steam-jacketed pan to about 160°-180°F. and blowing in steam through the meal.

In dealing with certain oils which are easily separated and especially with oils used in cookery and otherwise consumed, where it is desirable to preserve the pleasant, bland, and faintly fruity taste, the ground oleaginous meal is taken direct to the press and pressed for cold-drawn oil. The cake from such cold pressing, as it still retains a large proportion of oil, is subsequently broken up, reduced to meal, and heated;

after this it is again subjected to pressure to obtain a further flow of oil. Ordinarily, however, the meal is artificially heated previous to any pressure and it depends greatly on the nature of the seed and the method of expression adopted. The warming of the seed meal renders the contained oil more fluid and consequently more readily separable with moderate pressure. It also yields the highest proportion of the contained oil, coagulates and holds back the albuminous constituents of the seeds and similarly dries and retains the mucilaginous matter. On the other hand, the oil obtained from the heated meal becomes highly coloured and of inferior taste to that obtained by cold-drawn process. The quality is seriously affected if by chance the heat applied exceeds 80°C . When the meal has been cooked, steam is injected, the presence of which to a certain proportion assists in the subsequent operation.

PERIOD OF COOKING.

The period of cooking however is determined by various circumstances. If the seed being treated is freshly gathered, or is more than usually wet from this or from any other cause, it will require more cooking than dry seed, in order to remove the excess moisture. If the cakes are to keep, the quantity of moisture that can be left in the seeds must not exceed a certain figure which varies according to circumstances between, say, 11 per cent. and 13 per cent. Therefore extra cooking power is necessary when the seed is more than usually wet. In some cases seeds rich in oil are pressed first in cold and the residue afterwards cooked and expressed.

MOULDING.

The crushed seeds are then moulded to compress the loose ground material into the smallest volume

possible without forcing out the oil. For this purpose steam suffices to produce the requisite pressure. By means of this process of moulding, the oil presses can be charged with a maximum amount of material, whereby their efficiency is raised to its highest limit. The object of moulding is therefore to economise time and power.

The heated seed is fed into the hopper from the outlet of the heating kettle. The feed box is then drawn over an opening in the slide, through which the meal falls on to a press cloth spread over an iron table resting on a sliding frame. The slide is then lifted up, the material enveloped in the cloth and pushed on to the pressing table. Contact is thereby made with the lever of the throttle valve admitting steam to the cylinder; the piston rises and presses the material on the table against the upper plate. After the pressure has been continued for a few seconds, the steam is released by opening the exhaust pipe and the press table sinks. The slide is again lowered, the iron plate carrying the cake drawn on one side, and the latter is transferred to the oil press for further treatment.

PRESSING.

The moulded cake is then pressed after being placed in bags carefully placed in exact position between the press plates. The Anglo-American Press is usually used because it is comparatively simple and straight forward in design and possesses some well-marked advantages. Running in conjunction with a modern meal moulding machine it is easily and quickly loaded. Moreover, it is easily unloaded after the meal has been pressed. The material is then compressed, and the oil is extracted. The pressure usually applied is $1\frac{1}{2}$ to 2 tons per square inch. But the

greatest disadvantage in this system is that the cakes cannot be easily stripped from the press bags. It involves considerable labour, hence in the most modern mills the operation is carried out mechanically.

The pressing operation is sometimes carried on successfully in cage presses; the method employed is the same as described above. A description of the cage press will be found on *page 46*.

In recent years various types of oil expellers have been in use and in several factories the treatment of seeds is carried out economically and successfully with this machine. Seeds can be pressed cold without crushing, but of course, the best results are obtained by rolling the seed and heating the meal as in other method of pressing.

For such seed, rich in oil, the best arrangement is to use the cage press for first pressing and the plate press for the second pressing.

In many cases the residue from the presses, "oil-cake," is a valuable cattle food and in such cases the greatest pressures are not used so that a reasonable percentage of oil may be left in the "cakes." Such cakes are sold on the basis of the amount of oil and albuminoids which they contain.

PARING.

The cake as coming out of the press has its edges very oily, sometimes this oil content varying from 30 to 40 per cent. These oily edges are cut off by the paring machine. The cake is thereby given a symmetrical appearance. The parings are taken under a very small set of edge-runner mill-stones, which automatically discharge them, when sufficiently ground, into an elevator leading to the kettle, where they are worked up with fresh seed.

OIL RECOVERY.

In the hydraulic press system, on account of high compression, lumps of meal full of oil come out of the open sides of the bags and accumulates in the tanks in which the press stands. This material is known as "foots." To avoid wastage some manufacturers take out these oily lumps, and directly mix with the heated meal in the kettle. This is a wrong procedure, resulting in the fresh lot of meals in the kettle being vitiated. The best and only method is to extract most of the oil from it by means of centrifugal machine, and then to transfer the residue to the kettle.

Detailed methods of expressing the oils with special bearing to linseed, castor, groundnut, etc. are given in separate chapters which follow later.

CHAPTER VII

PRINCIPLES OF OIL EXTRACTION.

WE now pass on to describe the second method of recovering oils from vegetable substances, namely, their extraction by means of chemical solvents, such as benzine, ether, chloroform, carbon disulphide, carbon tetrachloride, etc.

In ordinary pressing about 10 per cent. of oil remains behind with the cake while by means of solvents nearly the whole of the oil may be extracted. Solvents might therefore be used for extracting the residual oil from the finished cake or they can be employed with advantage for treating unpressed seeds. As a matter of fact it is desirable to leave a certain percentage of oil in the cake, which is to be used for feeding purposes, because its food value depends on the extent of the fatty matter present in it.

.. Chemical extraction is particularly applicable to seeds, the oil and cake of which are used not for edible but for technical purposes; for there is a distinct gain in the larger yield of oil and also the freedom of the meal from oil. The fat free meal is superior in quality as a manure. In England the bulk of castor seed is treated by the extraction process.

The residue from the solvent process, which is in the form of a meal, may contain as little as $\frac{1}{2}$ per cent. of oil, or in some cases up to $1\frac{1}{2}$ to 2 per cent. Actually, it is possible to extract the whole of the oil; but as the cost of taking out the last traces of oil is more than the value of the oil produced, the process is only carried to what may be termed the economical limit,

which varies with different materials between the points stated above.

COMBINATION OF PRESSING AND SOLVENT PROCESSES.

In some instances a combination of pressing and solvent plants is employed, as for example to treat castor seed when a high quality medicinal oil is required. For this purpose, the medicinal oil is first expressed by cold pressing. The cakes from this pressing are then broken up, and further treated in a solvent extracting plant, which extracts practically the whole of the remaining oil, less than 1 per cent. usually being left in the residue.

THEORY OF SOLVENT EXTRACTION.

The theory of solvent extraction is that when ground oleaginous seed is saturated with some suitable chemical solvent, the oil is dissolved by the solvent and can be drained off with it. The mixture of solvent and oil is then subjected to heat to evaporate the solvent and separate it from the oil. The vaporised solvent is then condensed and used over again. The process therefore consists of:—

(1) The preliminary preparation of the seed so that the solvent may easily penetrate the oil cells.

(2) The solvent, either in the form of cold or hot liquid, or in some cases as a vapour, is allowed to percolate through the ground seed, which is contained in an enclosed pan.

(3) The mixture of oil and solvent is drained off into an evaporator.

(4) The solvent is driven off by the application of heat, passing as a vapour to the condensers, where it liquefies and is ready to be used again.

(5) The residue in the form of meal is treated by steam to remove from it any remaining solvent, which also passes as a vapour to the condensers to be recovered for further use.

NATURE OF SOLVENTS.

An ideal solvent should be neither inflammable nor explosive; it should dissolve the oil content of the crushed seed; it should not disintegrate when distilled off, and it should vaporise with the use of only a small amount of heat; it should not give off noxious vapours which again should be practically non-inflammable; it should not cause any chemical change in the material under treatment, nor have any deleterious effect on the plant; it should possess low boiling point and hence it can be easily separated out from the oil by simple distillation and on condensing it may be used again and, finally supplies must be readily obtainable at a low cost. Needless to say, none of the solvents known fulfils all these conditions.

Some of the principal solvents in use are benzine, benzol, trichlor-ethylene, carbon tetrachloride, and carbon disulphide. Of these, benzine is the one chiefly employed particularly in the vegetable oil industry, on account of its general suitability, its comparative cheapness, and the fact of its being available in large quantities. Benzine, specially prepared for the vegetable oil industry, is offered by the principal petroleum companies.

Other solvents in use are carbon bisulphide and petroleum ether, whilst carbon tetrachloride and the chloro-ethanes and chloro-ethylenes have been proposed more recently, although their comparatively high cost mitigates against their general use, in spite of their obvious advantages.

PRELIMINARY PREPARATION OF THE SEED.

After cleaning, the seed is ground in practically the same way as for a pressing plant, in order to break the oil cells. The necessary grinding machinery varies according to the materials to be treated. Many small seeds, such as soya, linseed, cotton seed, rapeseed, etc. can be handled quite efficiently in the Anglo-American 5-high Rolls. Larger seeds or nuts may call for preliminary reducing machines before they go to the Anglo-American Rolls for final grinding. Under this section also must be mentioned the decorticating machines necessary for such materials as groundnuts, which require to be unshelled before treatment. The grinding machinery should preferably be installed in a building separate from the actual extraction plant.

From the grinding house the ground materials are delivered to bins situated above the extraction vessels in the extraction house. From these bins the material is charged to the extractors as required, and when charged the vessels are sealed up.

EXTRACTION.

The solvent from the store tanks is admitted to the extractor, to which it can be supplied either hot or cold, or as a vapour, as may be required. When the extractor has been charged with solvent, it is allowed to drain down. The mixture of oil and solvent in which the solvent is not fully saturated is passed to a mixed solvent tank, from which it is used for the subsequent first "washing" of a new charge of seed, and by this means all the solvent is used fully saturated.

The charging with solvent and draining down is continued until the drained liquid shows no signs of oil. There the residue remaining in the extractor is thoroughly treated with steam to remove from it all traces of solvent.

The discharge door is then opened and the stirrers quickly remove the meal from the vessel, and it passes automatically to the drying machine. After drying and cooling, it is finally dealt with in an automatic sack-filling and weighing machine.

The use of a separate drying machine is recommended wherever it is desired to reduce the moisture in the extracted meal to a given point, or to control the amount of moisture in the meal within certain limits; other methods employed in extraction plants do not allow of this being done.

EVAPORATING THE SOLVENT.

The oil and solvent from the extractor is treated in the evaporator to vaporise the solvent, which passes to the condensers to be liquefied and returned to the solvent store. The oil is further treated with steam to remove all traces of solvent and is then pumped to the oil store.

Provisions should be made to prevent any avoidable loss of solvent and to bring the loss in working down to the absolute minimum. All the drains and outlets from the plant are carefully trapped to recover any solvent which may be carried off.

A plentiful supply of water is necessary for a solvent extraction plant, to ensure an adequate supply of cooling water for the condensers and to supply the boilers.

MOTIVE POWER.

The motive power for a solvent extraction plant can be supplied from any type of engine or from electric motors. An ordinary steam engine is usually preferred as a supply of steam and the exhaust steam can be utilised in the extraction house towards vaporising the solvent.

CHAPTER VIII

REFINING OILS.

THE art of refining oils has long been looked upon as a mysterious business, requiring great skill to carry out the operations successfully owing to a good deal of secrecy commonly exercised by the refiners.

Oil refining may be properly regarded as constituting a separate industry by itself. It requires the possession of a considerable knowledge of chemistry, for each type of oil in general has to be treated in a special manner. Moreover, the refining must be carried out to varying degrees of fineness as the selling price usually depends upon degrees of purity.

IMPURITIES IN THE OIL.

Vegetable oils, as first expressed, are in a crude state, varying in quality and colour according to the condition of the seed and how it is treated. The care taken in working also determines the quality and colour of the oil.

The crude oil may contain various impurities and certain objectionable chemical elements either held in suspension or in solution. It may be dark in colour due to the presence of the fleshy portion of the seed or the husk of the seed at the time of extraction; they can contain dirt or vegetable fibrous matter or mucilage or other foreign bodies which make their passage at the time of crushing; they sometimes contain free fatty acids or free glycerine caused by some portion of the oil absorbing water and getting hydrolysed. The free stearine in the body of the cotton seed and other

oils is also likely to be deposited on a cold day when the temperature falls. This renders the whole oil dirty in colour. This stearine is to be eliminated if the oil is to be used for burning, lubricating or edible purposes.

DIFFERENT PROCESSES FOR REFINING.

It will be thus found that the process employed in oil refining is either mechanical or chemical or a combination of both. For example, the foreign impurities in the oil and the mucilageous substances are eliminated mechanically. The bleaching operation in general requires a chemical treatment but this is frequently accomplished by what is really a mechanical process. Free fatty acids can only be removed by chemical means.

NECESSITY FOR REFINING.

Practically all crude oils require to be refined in some way before use, the degree of refining necessary varying in almost every case according to the purpose for which the oil is to be used. Thus oils for soap making or industrial purpose or for ordinary culinary work should be neutralised and rendered free from any trace of fatty acids; oils for use in perfumes, paints and varnishes should not only be neutralised but also bleached and where the oils are intended for edible use the process should be carried further and the oil deodorised under vacuum in order to remove any objectionable taste or smell.

BLEACHING, DEODORISING, ETC.

The mechanical and chemical processes of filtering, removal of fatty acids, purification with soda, bleaching and deodorising are discussed in the following chapters.

CHAPTER IX.

FILTRATION OF OILS.

TO remove the solid impurities, it is first of all necessary to allow the oil to run into tanks and to stand undisturbed for several days. Much of the impurities and dirt held in suspension deposits at the bottom of the vessel. The upper layer of the oil then becomes much clearer and can be decanted or drawn off with the help of a syphon. Sometimes as in the case of linseed the oils are tanked for months at a time.

A PRELIMINARY TEST.

As the method of decantation involves loss of time and storage space and investment of a huge amount of capital, it is never carried too long. Only after a few hours, the oil is decanted off and then subjected to filtration. Preparatory to this a simple experiment should be performed with a small quantity of the oil. The result of filtration of the oil through filter papers or a piece of flannel fitted into a funnel is noted. If the oil becomes thereby brilliant, simple filtration will be sufficient for the purpose but if after filtration the oil still contains an excess of albuminous matters, the oil is to be coagulated and precipitated before the operation of filtration can be undertaken. Various methods of ensuring coagulation are in practice, such as dry heat, introduction of fine jets of steam, or the addition of a small quantity of fuller's earth which as it subsides attracts and carries down simultaneously the albuminous matter in the oil.

If the oil is found by test to emerge out clear through the filter press, the oil requires no previous coagulation. Simple filtration through filter presses is found in such cases to be sufficient for ordinary purposes. But if the oil still shows dark colour or turbidity, the oil requires to be passed through a filter press.

WORKING OF FILTER PRESS.

Usually the pressure is applied by hydraulic power to force the oil through the plates. In some forms of the apparatus advantage is taken of steam power to apply pressure. There is also another form of filter press in which the oil is introduced from below into a chamber and rises upwards through the filtering medium into a compartment in which a partial vacuum has been created.

Some filter presses are equipped with a series of square or circular plates but now-a-days those with square plates are considered more economical of the two. The plates are of the recessed type having central feed inlet and the filtrate is delivered from a plain bit on each plate into a sheet steel gutter. The filtering surface is either grooved or of pyramid pattern. The filter cloths are secured round the central feed hole by special instantaneous pattern cloth clips.

The machine may be kept in daily use without opening for a week. At the end of the time the machine is allowed to stand about three hours. The cakes collected on the surface of the filter cloths can then be easily detached. On being screwed up again, the filter is ready for work. An additional pump may be attached to the filter press for pumping away the oil as fast as it is filtered.

The filter press is adjusted and the crude oil is pumped into the press at the right-hand end, and allowed to flow through the central feed holes to fill all the chambers between the plates. Now under the pressure of the oil, the filter cloths are pressed backwards until they meet the support of the plates. Since the faces of the plates are formed with vertical grooves connected by short horizontal grooves, the oil filtering through cloths may trickle downwards into a gutter formed along the plate just above the lower raised edge. From this it is conducted through openings into a central passage to a collecting trough.

After using the press for a good length of time the filter cloths are found to be clogged with various impurities so that it is desirable to remove and clean the press filter cloths occasionally, and particularly when the oils are to be used for edible purposes. The filter cloths on removal from the press are transferred to a washing machine, where they are treated with a hot dilute solution of caustic soda which combines with the oil and produces soap and thus cleanses the cloths from mucilage and dirt.

ADVANTAGES OF FILTER PRESSES.

The advantages to be derived from the use of filters are now definitely established. These are now in use in all up-to-date mills. The enormous loss of time and the store space necessitated by the old method of allowing the oil to settle are entirely done away with. In addition, the production of foots is avoided so that the only products of the machinery are bright oil and cake. The residue from the filter is worked over again, going either directly to the kettle or first through the centrifugal separator and then to the kettle.

REMOVAL OF MUCILAGE BY HEATING.

Previous to the invention of filter press the solid impurities were generally removed either by heating or by prolonged storing so that the mucilage settled at the bottom leaving the clear oil on the top.

On a small scale the removal is effected by heating the oil in a special type of cast iron pan built into a flue in such a way that the hot gases strike the sides rather than the bottom of the pan. The vegetable matter on precipitation, sinks to the bottom, and if the heat is applied just at the bottom of the boiling pan, the vegetable matter becomes charred and this injuriously affects the quality and colour of the oil.

Heating must be done very carefully to drive off all the moisture present in the oil. In no case overheating should be done. If the temperature becomes comparatively high a little water should be added to the oil. When free from moisture the oil is allowed to cool and settle.

\ On a comparatively large scale, the operation can be carried out in steam-jacketed tanks having a jacket all round the sides, but not on the bottom. The bottom should be conical in shape. The vessel is provided with a mechanical agitator. Closed steam coils are however unnecessary, and only lead to carbonisation of vegetable matter and consequent injury to oil. Heating is generally done by passing steam at atmospheric pressure through the jacket. When free from moisture the oil is allowed to cool so that the solid impurities are collected in the groove of the conical portion.

As on the large scale this slow settlement of the precipitate is not practicable, a filter press is necessary to do the job very satisfactorily.

CENTRIFUGAL MACHINES FOR FILTRATION.

Filtration of oils can also be accomplished by means of centrifugal machines which are equipped with a jacketed chamber with a perforated wall. The chamber is capable of rotation and the walls of it are wrapped round with a filter cloth. The oil is introduced in the chamber which is then allowed to rotate. The oil is flung against the wall of the revolving chamber and passes through the filtering medium into an outer chamber. The filtered oil can be withdrawn from the chamber.

REFINING WITH SULPHURIC ACID.

The materials used as filtering media include sand, kieselguhr, fuller's earth, animal charcoal, and vegetable fibres disintegrated into a pulp.

Sulphuric acid is also employed to refine and clarify the oils. The sulphuric acid chars the impurities present in the oil completely after some time. On allowing the oil to stand a watery acid liquid separates at the bottom with a layer of flocculent "foots," above which is the clear oil. The oil can then be drawn off and washed with warm water. Rape and linseed oils are most usually refined by the acid process.

CHAPTER X.

REMOVAL OF FREE FATTY ACIDS.

BY the removal of the free fatty acids, the oil is deprived of the elements which impart to it a characteristic odour and taste and render it liable to decomposition. This also improves the colour of the soap.

The standard method of removing the fatty acids is to agitate the oil with caustic soda solution and to carefully regulate the temperature of the oil. The soda solution combines with the free fatty acids to form a soap, which falls to the bottom of the vessel. The agitation is then stopped and the neutralised oil is run off from above and washed.

CALCULATION OF ACIDITY OF OIL.

But first of all a trial experiment should be made to ascertain the quantity of caustic-soda to be added to the oil to have it completely neutralised. To arrive at this figure, it is necessary to have a preliminary idea of acidimetry and alkalimetry and a fair knowledge of trituration. First of all, it is necessary to prepare a solution of caustic soda of known strength by dissolving a weighed quantity of the soda in a definite quantity of water. The usual custom is to dissolve about 1 part of caustic soda in 250 parts of water. Water is taken in a measuring flask and caustic soda is added weighing about 1/250th part of water. From this the percentage strength of the caustic soda is known.

Now a measured volume of the soda solution is taken in a graduated burette which is clamped vertically. A quantity of the oil, say, 1 chhatak is taken in a porcelain crucible which is put just underneath the orifice of the burette. A few drops of phenolphthalein are added to the oil, when due to the presence of free fatty acid the oil is coloured pink. Now the oil is triturated with the soda solution. The soda solution is allowed to fall drop by drop and the colour of the oil in the basin is observed. So long as the colour retains its pink characteristic, it must be known that there is still some free acid unneutralised and more solution is to be added. More caustic soda is added gradually till the colour is just discharged. Trituration is stopped at once and the readings on the burette are recorded. This simple experiment gives the quantity of caustic soda required to neutralise one chhatak of oil. From this by an easy calculation the total quantity of caustic soda required for neutralisation of the total bulk of the oil can be determined.

ANOTHER PROCESS.

The following method of determining the percentage of fatty acid in the oil has been suggested in a Bulletin published by the Department of Industries, Madras.

An open iron pan or tin can capable of holding 3 or 5 bottles of water is taken, a bottle (24 oz.) of water is added and heated over a gentle fire. When hot, an ounce of oil correctly measured is poured over it. A teaspoonful of moist turmeric powder is added to the water and well stirred (a few drops of phenolphthalein dissolved in spirit may also be used). To this is added slowly ounce after ounce, a 1 per cent solution of washing soda (i.e. one pound washing soda dissolved

in $2\frac{1}{2}$ kerosene oil tins of water). The solution formed by the addition of soda will turn temporarily brown but immediately changes to the yellowish tinge of turmeric provided any rancid matter remains free. When it has completely combined with soda and the latter is in excess, the solution will have a pinkish brown tinge permanently. From the number of ounces of washing soda solution used and its strength, the weight of washing soda used can be calculated, as also the quantity of washing soda required for known weight of oil. The percentage of rancid matter or free fatty acids is roughly $5\frac{1}{2}$ times the weight of soda used.

PROCESS WITH CALCIUM HYDROXIDE.

The following process involving the use of calcium hydroxide solution (lime water) for estimating the acidity of oils has also been recommended. It is well known that calcium hydroxide is sparingly soluble in water and the solubility decreases with increase of temperature. The solubility at 25° - 30°C . is just twice that at 95° - 100°C . The former solution when added to rancid oils previously shaken with alcohol or methylated spirits and a few drops of a test solution represents in a simple volumetric ratio, the percentage of acidity and the latter solution at 100°C bears a simple relation to acid value, e.g., 1 volume of oil of 5 per cent. acidity requires 5 volumes of calcium hydroxide solution saturated at 25 - 30°C and 10 volumes of the same saturated at 100°C .

Fresh quicklime prepared from good shells is available in the villages all along the sea coast of India. A saturated solution can be easily prepared by taking a tola or two of fresh lime and shaking it with water nearly filled in a 24 oz. bottle and filtering the top

layer over a cloth to remove any stray particles floating in the liquid. The indicator that serves best is phenolphthalein and the end point is that at which the colour (pink) persists even after long shaking.

Quantities of sodium carbonate and sodium hydroxide required for 1,000 lbs. of oil having acidities varying from 1 to 15 per cent. are given in the following table:—

ESTIMATION OF THE FATTY ACIDS.

P. C. of Acidity.	Washing Soda.	Caustic Soda.	Wood Ash.	Potash Carbonate
	lbs.	lbs.	lbs.	lbs.
1	1.9	1.4	65	2.5
2	3.8	2.8	130	5.0
3	5.7	4.2	195	7.5
4	7.6	5.6	260	10.0
5	9.5	7.0	325	12.5
6	11.4	8.4	390	15.0
7	13.3	9.8	455	17.5
8	15.2	11.2	520	20.0
9	17.1	12.6	585	22.5
10	19.0	14.0	650	25.0
11	20.9	15.4	715	27.5
12	22.8	16.8	780	30.0
13	24.7	18.2	845	32.5
14	26.6	19.6	910	35.0
15	28.5	21.0	975	37.5

NEUTRALISATION WITH SODA ASH.

After ascertaining the acid value or in other words finding out how much caustic soda or sodium carbonate is required for neutralising the free fatty acids in any oil the treatment in bulk can be taken up.

For carrying out the refining operations, small tinned copper or galvanized iron vessels only are needed. If these are of cylindrical shape, the sedimentation, etc., will be facilitated. A four-gallon drum will fairly answer the purpose. One or two 1" iron or brass cocks should be fitted on the side of the cylindrical vessels for drawing out the liquid. Two or three vessels should be provided, one for mixing with soda and the rest for washing purposes. These should be of a slightly bigger size. The vessel in which the refining is to be carried out is kept $\frac{1}{2}$ or $\frac{3}{4}$ full of oil and gently heated over an open fire to 45° - 50° C. The soda ash (sodium carbonate) is dissolved in water to form a 10 or 20 per cent solution and this should be kept ready at hand. The quantity of solution required, which can be ascertained by reference to the table given above, is added slowly in a thin stream to the oil. The mixture is well stirred and kept warm till combination takes place as indicated by granules of soap gradually going down. The mass is now allowed to rest for some hours; the soap sediment will be deposited as a solid cake or jelly at the bottom of the pan. The clear oil on the surface is drawn off and washed twice or thrice with some warm water till the solution is free from traces of soap. The oil thus obtained can be filtered over cloth to remove traces of moisture or the latter can be driven out by heating to a temperature of 110° - 120° C. The oil will be found to have an agreeable flavour and taste and a fairly light colour and is ready for packing into containers which being soldered well the oil will remain good for months.

NEUTRALISATION WITH WOOD-ASH.

When using wood-ash lye it is better to warm the lye first and add the oil to the hot solution. Com-

bination will take place fairly quickly. The oil will be found to float as a distinct layer over the soap emulsion. The oil is skimmed off and washed with warm water till traces of soap are removed. The removal of moisture is similar in all cases. In treating with wood-ash lye, the soap formed from the free fatty acids is completely dissolved in the lye and very little of good oil is carried with it. Hence the loss during refining is not much, this amounting only to about one and a half times that of the free fatty acids.

NEUTRALISATION WITH CAUSTIC SODA.

The above process can also be adopted for caustic soda, but the quantities should be very carefully calculated as otherwise there will be much loss of oil in the shape of soap stock.

It must be understood here that more caustic soda has to be added to the oil than is theoretically necessary to neutralise the percentage of free acid revealed by actual analysis. The surplus soda does not, however, attack the neutral oil unless the amount of alkali present is much in excess. The reason lies in the fact that the action between a given amount of caustic soda and a given quantity of oil will cease at a stage when the chemical action between the soap formed and the oil and alkali is in a state of equilibrium so that the surplus caustic soda and oil are still left uncombined. The only point to be considered is the influence of temperature at which the reaction is conducted.

LOSS OF OIL.

In the case of treatment with washing soda and caustic soda a part of the good oil besides free fatty acids will be acted upon and a part of it will also get

occluded with the crude soap, reducing thereby the yield of refining oil, or, in other words the refining loss will be greater. Such loss may be taken as representing about 2 to 2½ times that of the percentage of acidity. These residues containing oil mixed with caustic soda or sodium carbonate and impurities are known as foots or soap stock, and are readily saleable to manufacturers of washing soap.

THE PROCESS IN PRACTICE.

To achieve better results it is, however, desirable to agitate the oil, while it is being treated with caustic soda, with the aid of heat to accelerate the chemical reaction. The operation is conducted in a neutralising vessel consisting of a steam-jacketed mild steel vessel with conical bottom. The vessel has an internal tube in which is fixed a series of screw propellers, which circulate the oil very rapidly and ensure perfect admixture of the caustic soda with the oil. The vessel is fitted with swivelling draw-off pipe, which allows the oil to be drawn off, and permits necessary adjustments to be made to avoid any risk of drawing off the soap which has settled out of the oil after neutralisation.

In practice, the oil is put in the neutralising vessel which has been raised to a suitable temperature (usually, 30°C) by passing steam through the jacket. The oil is agitated by means of screw propellers, and the quantity of caustic soda solution (74°Be) found to be sufficient for neutralisation is added whilst the oil is in a state of agitation. The combination of the free fatty acids with caustic soda solution forms a flocculent soap. When the oil becomes clear and no more soap is formed, the agitation is stopped. The mixture is then allowed to stand until a sediment of coagulated albuminous and mucilaginous matter from

the oil falls to the bottom of the vessel with the excess of caustic soda. The oil is cooled and then run off through the draw-off pipes. In order to minimise the risk of drawing off any of soap solution, the oil is at this stage passed through a filter press. The oil is then washed free from caustic soda with a stream of water.

WASHING WITH WATER.

The wash water is withdrawn from the bottom of the kettle until oil comes; then fresh water is added and the process is repeated until the oil is free from alkali. During this operation mechanical agitators are used in order to thoroughly mix the oil and water.

Finally moisture is expelled by heating the oil gently by steam pipes to a temperature not higher than 50°C , while a current of air is blown through. The last traces of moisture are sometimes removed by adding plaster of Paris and filtering. Filtration through a layer of common salt also removes all moisture.

WASHING THE OIL.

Another method of washing the oil follows:—

After the neutralisation of free fatty acids the substances left in the kettles consist of a mixture of acid free oil, surplus caustic soda solution and the soap formed during the chemical reaction. The mixture is allowed to stand for some hours to permit the soap, soda solution and any remaining mucilage to sink to the bottom, while the oil occupies the upper layer as a clear liquid, which is then drawn off for further treatment. The solid residue left in the kettle should not be thrown away but be sold to the soap maker as "soap stock." To facilitate the settling out of the

soap, etc. from the oil, salt is sometimes thrown into the kettles, for soda soap is insoluble in salt water.

The clear oil thus obtained is next washed with water to remove all traces of soda from it. Thereafter it is treated, as above, to drive off any volatile fatty acids still adhering to it as well as the last traces of moisture which find their way at the time of washing.

REFINING ON A SMALL SCALE.

In refining with caustic soda, on a small scale, the oil is mechanically stirred with the caustic soda solution (sp. gr. 1.1) with or without the aid of heat, and the mixture is then allowed to stand until it separates into two layers, the lower of which contains a sediment of impurities. This is drawn off and the treatment repeated but this time with a more dilute solution of alkali, and finally the oil thus clarified is washed with water to remove the excess of alkali.

WASHING WITH SULPHURIC ACID.

Oils may also be purified by washing with a solution of sulphuric acid. The oil is pumped into a lead-lined tank. About 2 per cent of sulphuric acid of 66°Be mixed with an equal volume of water is run into the oil. The liquid is agitated by an air blast, warmed for about one hour, settled, the acid run off at the bottom and the oil washed with water and caustic soda until free from acid. Finally the clear supernatant oil is decanted and filtered.

LIME AND MAGNESIA.

Lime and magnesia are sometimes used for neutralising the fatty acids. The method of treatment of the oil is the same as in the case of the caustic soda. In that case insoluble calcium and magnesium soaps are formed. In some cases the oil is first

neutralised with caustic soda or sodium carbonate, decanted from the resulting soap, a small quantity of strong acid added to decompose any soap remaining and the oil finally neutralised with lime, magnesia or baryta. The resultant insoluble soaps are removed by passing the mixture through a filter press.

WASHING WITH POTASH CARBONATE SOLUTION.

Potash carbonate may also be used to remove free fatty acids responsible for rancidity of the oil. As a working rule it may be stated that to neutralise 1 per cent of acidity present in 1,000 lbs. of oil, 2.5 lbs. of potash carbonate will be required.

The alkaline liquor (foots) contain a quantity of soap and oil which is recovered by acidifying and then removing the fatty layer which rises to the surface. Where both acid and alkali refining is carried out in the same works it is customary to mix the acid and alkali foots to produce a neutral or faintly acid mass from which the fatty matter readily separates.

CHAPTER X.

BLEACHING OILS.

BY the refining process the oil is cleared by much of its dark colouring matter and the constituents that cause turbidity. But still a brown colour persists. If the oil is required for soap making, no more operation need be undergone. But if the oil is intended to be put to edible purposes it should be bleached and deodorised.

Before the actual process of bleaching is taken up, as a general rule, the oils are first subjected to refining after which they are much lighter. In the case of oils such as groundnut and sesame the colour of oil after refining is sufficiently light but in the case of cotton seed oil, especially from old seeds, the colour of the oil will be considerably darker than the refined oil obtained from American seed. To obtain a paler oil, bleaching with fuller's earth must be resorted to. After the oil has been free from moisture about 5 to 6 per cent. of fuller's earth is stirred in and mixed vigorously with the oil for about twenty minutes, after which the mixture is pumped through a filter press to remove the fuller's earth. Considerable variation from the above or standard practices may be and are often introduced into the operations of refining.

Oil may be bleached by the action of sunlight alone; and oil so prepared is far superior to any chemically prepared oil. A thin film of oil in direct sunlight bleaches in two hours. On a commercial scale bleaching by sunlight requires about two weeks. Exposure to the air also partially bleaches the oil.

Chemically bleached oil does not wear as well as raw oil; any admixture whatever of foreign matter seems to have detrimental effect upon the characteristic properties of linseed oil. Acid-bleached oils do not break, because the acid attacks and chars the elements which would otherwise separate upon heating and permits of being removed by filtration.

BLEACHING AGENTS.

Chloride of zinc, calcined magnesia, steam, hot air, tannin, salts of iron or alumina, lye, and sulphate of manganese have been variously recommended as refining agents; some producing primarily a bleaching effect, others a breaking of the oil at low temperature. Bleaching agents, besides those already mentioned, are the permanganate and bichromate of potash, linoleate of manganese, nitric acid, caustic soda, carbonate of potash, ferrous sulphate, basic lead acetate, lead sulphate and various complex mixture. Chlorine gas is probably the most effective and rapid of all bleachers, but can be separated from the product only with great difficulty.

The chief bleaching agents in use are charcoal, fuller's earth, hydro-sulphite, and chemicals liberating chlorine or oxygen. Oils for edible purposes should be bleached with fuller's earth.

BLEACHING WITH CHARCOAL.

Bleaching the oil with charcoal is mostly adopted by the small scale workers. It is surprising to learn that the bleaching is effected by purely mechanical means. The fact is that the colouring matter in the original seed is in the form of a powder and passes as such into the oil. It can therefore be absorbed and held back by the earth or charcoal. By this method

the bleaching of oil is accomplished by the direct removal of the colouring matter.

Before proceeding with the real operation, the charcoal requires some preliminary treatment. It should be first boiled with pure water and then some sodium carbonate or hydroxide is added to render the water alkaline and the boiling is continued. The charcoal is next washed to free it from the excess of alkali adhering to it and boiled for twelve hours with four times its weight of a mixture of equal parts of commercial hydrochloric acid and water. The charcoal is next washed free from acid. It is then dried and burned in closed vessel. The activated charcoal is then ready to be used for bleaching.

To bleach the oil, the charcoal is spread on the floor of a big vessel in granular form while it is still warm. The quantity of charcoal sufficient to bleach the oil is usually one to five per cent. of the oil under treatment. The oil is then introduced in the tank and thoroughly mixed with the charcoal. After a time the oil is allowed to settle and then drawn off.

BLEACHING WITH FULLER'S EARTH.

Treatment of oil with fuller's earth, not only helps to bleach the vegetable oils but also assists in deodorising it to a certain extent.

The principle underlying the process is to mix the fuller's earth intimately with the oil to be treated and subsequently to remove from the oil the fuller's earth together with all suspended matter. Heat, it has been found, quickens coagulation. The oil is thereby rendered clear and bright.

To ensure a most thorough incorporation of fuller's earth in the body of the oil, use is made of a mixing kettle which is usually jacketed on the bottom

only but is occasionally jacketed either partly or completely over the cylindrical surface in addition to the bottom. The additional jacketing may be taken advantage of where there is necessity of maintaining the heat of the kettle for a pretty long time. The kettle is provided with a mechanical agitator and steam coil. A filter press works near the mixing kettle and provision of a pump is made to transfer the batch of treated oil into the filter press in the shortest possible time.

MODE OF WORKING.

The kettle is first heated by admitting steam to the jacket, care being taken to see that the steam is allowed to blow freely from the outlet provided for draining out the condensed water from the jacket. The oil already heated to a temperature of 150°F., is then run into the kettle until this is filled to within about 4 in. of the top cover; the mixing gear is put to work in the meantime in order to agitate the oil and drive off any moisture contained therein.

The successful working of the process depends to a considerable extent upon the complete absence of moisture, and it is essential, therefore, that the oil, fuller's earth, filter cloths, etc., and the whole of the apparatus should be as dry as possible. The fuller's earth is added as soon as the oil in the kettle is at a temperature of about 150°F. It is important that the fuller's earth should be ground to a very fine powder. The quantity of earth necessary usually varies between about 2½ and 5 per cent. but it may be more or less according to the quality of the oil or fat being treated. The exact proportion can be determined by an experiment on a small scale. This experimental test will also enable the most suitable temperature to be ascertained.

It is advisable that the process should be worked at the minimum temperature found to give the requir-

ed result, as there is less danger of earthy flavour being imparted to the oil at a lower temperature. After a few minutes' agitation the earth will be uniformly and intimately mixed throughout the whole of the oil, and the feed pump on the filter press should then be started to work, and the whole batch pumped into the filter press in the shortest possible time. As soon as the filtering operation is finished, the fuller's earth remaining in the filter press, should be steamed out in order to recover as much as possible of the oil contained in the earth. This is done by opening the steam valve on the head of the filter press and allowing live steam to blow through as quickly as possible until the oil ceases to flow from the outlets of the plates. It is most important that the steam be as dry as possible, and to this end a drain cock should be fitted on the steam pipe just before it enters the filter press, and the steam pipe thoroughly drained out immediately before steaming out the press.

Immediately after steaming out, the press must be opened and the plates separated from each other, so as to leave an equal space between all the plates. If this is done, the heat contained in the iron plates will dry the cloths and deposit fuller's earth on same, so that the fuller's earth can be readily removed from the cloths without taking them off the plates, and will in this way leave the cloths quite clean and ready for a fresh charge.

BLEACHING WITH CHARCOAL AND FULLER'S EARTH.

It is advantageous to add a quantity of activated charcoal referred to above (p. 87) with fuller's earth for bleaching oils in which case colour seems to persist in spite of treatment with charcoal.

In such cases an addition of charcoal and fuller's earth in equal quantities is recommended.

BLEACHING VISCOUS OILS.

When dealing with viscous oils, such as castor, linseed, etc. the filter press should be previously heated to ensure that the temperature of the oil while passing through the filter press is not reduced below the point necessary for efficient filtration. This is most conveniently done by allowing steam to blow into the press and out from the outlet cocks, the press being first closed in the ordinary way. This is continued until the whole mass of iron contained in the plates of the press is thoroughly heated, and the press is then opened and the plates separated to allow all traces of steam to escape.

In order to remove the dissolved impurities in the oil, it is the usual practice to wash it with water, caustic soda or potash, milk of lime or magnesia. Dilute sulphuric acid is employed to clarify linseed for industrial purposes.

VACUUM WASHING AND BLEACHING.

To those who want to bleach the oil on a commercial basis, the method of vacuum washing and bleaching is to be specially recommended. In this process, the free fatty acid present in the oil is neutralised as already described and traces of soap left in the mass of the oil are then washed off and then treated for the elimination of the colouring matters still present in the oil.

For success in the vacuum treatment the oil, after being neutralised with caustic soda and filtered, should not be suffered to be exposed to the action of air as in that case the oil is liable to be oxidised. .

The washing and bleaching operation is conducted in a closed vessel constructed of mild steel and coated internally with pure block tin. They are provided with agitating gears and fitted with an internal steam

coil to raise the oil to the desired temperature. These vessels usually work under a vacuum of 10 to 15 inches.

In practice the oil as it comes out of the filter press after neutralisation is charged into the washing and bleaching vessel. The oil is stirred by means of the agitating gear and water is poured into it. The agitating gears continue working till the oil is washed clearly. The oil is then allowed to stand when the mixture separates out in two layers. The layer of water is then drawn off and the oil is cooled by means of circulating cold water through the internal coil till the oil attains a temperature not higher than 60°C.

The bleaching reagents such as fuller's earth, Kieselgurh are then added with constant stirring. The oil is thereby bleached and becomes light-coloured. As the oil is liable to get tainted with the bleaching agents due to its contact with them, it is advisable to remove the bleaching agents by filtration as soon as possible. Usually it is the practice of the refiners to carry on the operation of filtration as soon as a thorough admixture of the bleaching agents and the oil has been effected by constant agitation. The oil is then carefully passed through a filter press while the agitation still continues.

BLEACHING WITH SULPHURIC ACID.

Bleaching is also effected by dehydrating the colouring matter contained in the oil with sulphuric acid. This causes the charred masses to coagulate and hence they can be readily removed by filtration.

To 50 parts of raw oil there are added in lead-lined tanks $2\frac{1}{2}$ parts of sulphuric acid (66°Be). The mixture is agitated by air for 10 hours, and 8 parts of water are added. The mixture is steamed until it boils, then allowed to settle for 36 hours. The water

is run off through a reclaiming tank and the oil pumped to the filters. A shrinkage of about $1\frac{1}{2}$ per cent. is experienced.

BLEACHING WITH CHEMICALS.

Actual bleaching with chemicals is only resorted to in the case of inferior or very dark oils and fats. Bleaching by means of oxygen in a nascent state is usually effected by adding manganese dioxide or potassium bichromate and sulphuric acid. Sometimes bleaching powder or potassium bichromate, together with hydrochloric acid, is used when chlorine is evolved. The quantity of chemicals employed must be as small as possible, the time of interaction as short as possible, and the temperature as low as is compatible with efficiency.

In practice the oil is heated to a temperature of 38°C and is then pumped into a leadlined chemical treatment tank. Compressed air is now blown through it in order to thoroughly mix the contents while the requisite amount of 25 per cent. of potassium bichromate solution is run in. The mixing is continued for about one hour while the contents of the tank are simultaneously warmed by a steam coil. Finally the liquid is allowed to settle, the acid run off at the bottom, and the oil washed with water to remove acid.

TREATMENT WITH ANIMAL CHARCOAL.

One of the oldest methods of bleaching oil is to expose it to the action of animal charcoal in the presence of sunlight for a fortnight in a glass container of which the top is covered with a lid to prevent dirt, dust, etc. from coming in.

The process being a tardy one, the following method is recommended for quick results:—

The oil to be bleached is heated with 2 to 5 per cent of animal charcoal in a vessel over a water bath. This is to ensure that the temperature of the water does not rise over 212°F , above which temperature the oil is likely to get charred. The whole mass is stirred from time to time so that oil comes in touch with fresh surface of charcoal. The heating is continued for about an hour when the oil gets bleached. It is then strained through a cloth. The charcoal may be used over again after revivification.

OTHER METHODS OF BLEACHING.

The oil is first agitated with water containing gum, and to the emulsion thus formed is added coarsely crushed wood charcoal; the whole is then slowly warmed to a degree not reaching 212°F and when cold the oil is dissolved out by ether or petroleum spirits, and the latter is recovered by distillation; the result is good.

Bleaching by the aid of chlorine or oxygen does not secure the removal of colouring matter. Good result is however obtained by exposing the oil to the action of sunlight and air. This process results in the natural oxidation of the colouring matter, and is extensively adopted in the case of linseed and poppy seed oils. It is, of course, a very slow method. Recently, the bleaching of oils by means of ultra-violet rays has attracted some attention.

CHAPTER XII.

DEODORISATION.

AFTER the oil is properly filtered and bleached, it becomes clear, bright, limpid but it may still possess its characteristic smell.

REMOVING RANCIDITY OF OILS AND FATS.

Rancid and smelly oils and fats may be deodorised on a small scale by blowing them with a steam jet for some time in a steam-heated pan provided with mechanical stirrer; then the oils are kept stirring with a generous amount of good charcoal powders whilst warm, and finally filtered warm with some fresh charcoal through a washed calico filter or preferably through a handy patent filter. In case the rancidity be not very pronounced, it can be got over with a slight trace of pimento oil or nitrous ether, in combination with a little peru balsam or benzoin in the case of fats.

VACUUM DEODORISERS.

On a commercial scale, oils intended to be deodorised should be treated in deodorisers which may be either of atmospheric or vacuum type. In the former type the oil is subjected to the heat of both closed and open steam coils. The former raises the temperature of the oil to that of the steam, while the latter keeps the oil in an exceedingly vigorous state of ebullition so that the unpleasant odours escape into the atmosphere. In the vacuum type of deodorisers, the oil is similarly treated but at reduced temperatures

and pressures, and in consequence there is less likelihood of damage to the oil.

As a step preliminary to the real deodorising operation, the oil should be made as nearly neutral as possible, as oils showing excess of acidity cannot be satisfactorily deodorised and bleached. As soon as the oil is received from the filter press after being bleached, it is delivered into a pre-heater vessel. Like the washing and bleaching vessels the pre-heater consists of a mild steel vessel coated internally with pure block tin. The vessel is fitted with steam coil through which live steam may be made to pass to raise the temperature of the oil. Accommodation is made for a large diameter coil through which the vapour from the deodoriser may be made to circulate in order to utilise the heat of the vapours which otherwise escape into the atmosphere. There are also suitable arrangements for inspection covers and fitting sight glasses, thermometers.

The deodorisation of the oil is brought about by first putting the oil in vacuum deodorising vessel and raising its temperature to 100°C and then admitting superheated steam into the vessel. It is not at all necessary that the steam should be introduced at a high pressure, the only consideration being the provision of a large volume of steam maintained at a high degree of superheat. As a result of the injection of steam, the bulk of the oil is set in violent agitation and the volatile oils which are responsible for the odour of the oil escape. The oil is then tasteless and of an excellent colour.

The oil is then conveyed from the deodorising vessel to the cooler, which consists essentially of a mild steel vessel tinned inside, and fitted with a water jacket; until the temperature of the oil in the vessel

drops below 100 deg. C., it must not be allowed to come in contact with the air for fear of oxidation.

VACUUM PRODUCING PLANT.

The vacuum-producing plant may be either steam or power-driven, to suit existing conditions, and owing to the fact that a lower vacuum is desired in connection with the washing and bleaching apparatus than is the case with the deodorising vessels, it is usually found that there are two independent vacuum plants in most refineries. This portion of the plant must be efficient in action, for although an exceptionally high vacuum is not essential, it is advisable that a reasonably high vacuum should be readily obtained and maintained under actual working conditions.

It is generally found that a number of small deodorising vessels are more easily handled than one large one, and under such conditions a wet vacuum pump will be found sufficient to deal satisfactorily with the amount of steam used, but occasionally it is necessary to deal with large volumes of oil at one time, and in such an event it is customary to use both wet and dry vacuum pumps.

The length of time taken completely to refine and deodorise a batch of oil is from six to eight hours, but, this length of time may be reduced by the use of a larger quantity of steam during deodorisation.

DEODORISING BY LOW PRESSURE STEAM.

Objectionable odours in the oils may also be eliminated by passing low pressure steam thus:—Take a metal vessel, through the top of which enters a metal pipe and terminates just above the bottom of the can with perforated branches. The other end of the pipe is connected to a steam boiler. Now pour the oil to

be deodorised into the vessel and slowly allow steam to bubble through it for several hours. After this the oil is separated from water and passed through charcoal filter, when almost odourless oil is obtained. Many oils can be deodorised by this treatment but others again, especially the fish oils, retain their unpleasant smell most persistently.

CHAPTER XIII

PURIFICATION OF OILS FOR INDUSTRIAL PURPOSES.

WHEN the oil for soap making develops much rancidity, the fatty acids may be removed by boiling with spent lye. Simply boiling with water has been recommended by some chemists for purification of oils for industrial purposes but as the boiling operation is accompanied by vehement bumping due to passage of steam forming in the lower stratum of water through the mass of oil which forms the upper layer, it is advisable not to try this method.

BOILING WITH SPENT LYE.

For oils which have a bad odour with or without an objectionable colour, the oil is to be boiled over the spent liquor obtained on salting soap. It is essential that the spent liquor should contain enough salt to prevent the oil to be purified from forming an emulsion with the lye, or the dissolving, in the latter, of any soap which is formed as a result of the partial saponification of the oil with the caustic soda present in the spent lye. This process removes the odour to a great extent, unless the same is present in an excessive amount in which case a more rigorous treatment will be necessary.

BOILING WITH CAUSTIC SODA.

When the oil contains much odorous and colouring matters associated with resinous bodies, the simple boiling over spent lye containing a little free caustic

soda will not meet the end. An example of such cases is neem oil. In such cases it is not possible to have refined oils, for the treatment required amounts to saponification of the oils in order to deprive the odour and colour of their vehicles, the final product being soap free from the defects due to odour and colour. The following procedure is to be adopted in these cases. The oil is to be added to the spent lye and boiled to nearly complete saponification. This necessitates the addition to the spent lye of just enough oil which can be saponified by the free alkali present in it. It is sometimes an advantage to supplement the caustic originally present in the spent lye with fresh caustic to get through a larger quantity of oils and fats and to utilize the lye medium for the elimination of as much colouring and odorous matters as possible. When the saponification proceeds over the spent lye, the oil medium carrying the odorous and colouring matters is converted into soap with the result that the colouring matter is disengaged and discharged into the lye and the odorous matter escapes along with the steam. The oil thus purified and converted into soap is next added to the main soap charge for the production of high grade soaps consistently with the general quality of the raw material and without any of the disabilities due to the colouring and odorous matters.

FOR PERFUMERY.

Oils for perfumery may best be bleached by allowing them to percolate through animal charcoal or by exposing them to sunlight over a bed of animal charcoal.

PURIFICATION OF FISH OIL.

Fish oil is the principal oil derived from the animal kingdom in India. It is coming into greater

and greater demand due to its cheapness. Raw oil however has a bad odour about it and unless this can be removed the oil cannot be employed for industrial purposes. Being a non-vegetable oil, this does not properly come within the purview of the book but on account of its growing importance we give below a concise method of refining and deodorising it.

I.

One of the most effective ways of refining the oil consists in violently agitating the oil with boiling water or by placing it in a deep vessel with perforated bottom and forcing high pressure steam through it for some time. The oil is clarified by repose. It is pumped into a boiler and heated by steam to from 180° to 200°F . A current of air of corresponding temperature is then forced through it until it is sufficiently bleached and deodorised. Lastly it is filtered.

II.

Another method of refining the fish oil consists in gently heating the oil and stirring it for some time with about 1 per cent. of good chloride of lime previously made into a milk by trituration with water. About $1\frac{1}{2}$ per cent. of oil of vitriol diluted with 20 times its weight of water is then added and the agitation renewed and maintained for at least 2 hours. It is lastly well washed with steam or hot water.

III.

Still another method consists in boiling each ton of oil for half an hour with half pound of caustic soda, previously made into a weak lye with water. Steam is blown through the mixture for a like period. Sulphuric acid, half pound, diluted with 6 times its weight of water is next added, the whole again boiled for 15 minutes and allowed to settle for an hour or longer,

when the clear oil is run off from the water and sediment into the bleaching tubs. Here solution of bichromate of potash, 4 lbs., in sulphuric acid 2 lbs., previously diluted with water together with a little nitric acid and some oxalic acid are added. Then the whole is mixed well by blowing steam through it. Now strong nitric acid, 1 lb., diluted with water 1 quart is poured in and the boiling continued for half an hour longer. A small quantity of naphtha or rectified spirit of turpentine is then mixed in and the oil is finally well washed with hot water, and left to settle.

CHAPTER XIV.

LINSEED OIL.

LINSEED oil is prepared by a process of expression since the press cake is a valuable feeding stuff.

METHOD OF OIL EXPRESSION.

Cleansed linseed as are obtainable in the market on a basis of 95 % or 97 % purity do not require further cleaning, but seeds of lower value and considerably impure are passed through screening and seed cleaning machines for rendering them clean and free from foreign substances. The seed is then passed to the rolls or crushing machinery where the seed is ground and pulverised. After the seed is converted into meal, it is elevated into the kettle or heater where it is heated and tempered. The meal is here moistened and raised to a high temperature by means of saturated steam. This operation facilitates the flow of oil when in the press and solidifies any albuminous matter present with it. From the kettle the heated and tempered meal is drawn off into the moulding machine or *former* where it receives a preliminary pressing before being placed in the Anglo-American Press, which system is generally used for expression of linseed oil. As the cakes are moulded or formed by the moulder, they are taken from this forming machine on steel trays provided for this purpose. As soon as one press has been filled in the above manner by the press man, he turns on the hydraulic pressure to the press from the pumps or accumulators, as the case may be. With the rise of pressure in the press, the

oil begins to flow from the compressed meal, slowly at first and then very rapidly, gradually ceasing when the bulk of the oil has been removed and when the pressure has been on three or four minutes, the flow of the oil ceases practically, the oil simply dripping away from the now compressed cakes, until the pressure is turned off. If more presses than one are being used, they are filled one after the other, until the whole battery of presses is charged. The presses are allowed to remain under pressure for a fixed period, which varies under special conditions from 10 to 40 minutes, and when the proper time has elapsed, the first press in the series is turned down, i.e., the pressure is turned off and the ram allowed to descend, the cakes being removed one by one as the ram descends, and fresh charges of meal introduced wherever a cake is removed. As the cakes are removed from the presses by the pressman, they are placed on the paring machine or on a table near the paring machine. The man operating this paring machine then strips off the bags from the cakes, and pares the oily edges away from the cakes by means of the paring machine. These oily parings are reduced to meal again and returned to the kettle to be again worked up. The pared cakes are placed in racks in which they are allowed to stand until perfectly cool, when they can be removed to the cake house or store to be stocked or delivered to customers as occasion demands. The cake racks are usually allowed to stand in the most draughty part of the mill to assist the cooling process.

REFINING LINSEED OIL FOR PAINTS.

The linseed oil, if prepared according to the details supplied above, is fairly pure in character and does not require much refining. For the preparation of paint oils, the linseed oil, however, requires to be

refined by treating it with 1 or 2 per cent. of its weight of concentrated sulphuric acid which forms a charred product of the soluble proteins, resins, gums, etc. The oil thus refined varies in colour from yellow to very light orange, and if it be intended for artists' colours, it is to be bleached by mixing it with powdered lead and exposing it in shallow dishes to the action of sunlight. When linseed oil is required for the soap industry, the colouring matters may be removed by preliminary refinement with caustic alkalies. The above remarks apply only to warm expressed oil.

According to Thenard process in refining linseed oil, from one hundredth to one-fiftieth part (1 to 2 per cent.) of sulphuric acid is thoroughly intermixed with the oil in an efficient agitation at a temperature not exceeding 40 deg. C. (about 104 deg. F), and the whole allowed to rest for 24 hours. 60 to 70 per cent. of warm-water at about 60 deg. C (140 deg. F) is then well intermixed and the whole allowed to stand for some days; a watery acid liquid separates at the bottom with a layer of flocculent "foots" above which is the clarified oil. This is drawn off and again agitated with warm water to wash out any residual suspended vesicles.

BOILED LINSEED OIL

On heating linseed oil at 400°-500° Fahr. for several hours in contact with air and containing a small proportion of driers, its property of absorbing oxygen is increased. When exposed to air it therefore dries much more rapidly than raw linseed oil, and produces a hard lustrous coat. As this coat is liable to crack on exposure it is not advisable to use boiled oil alone.

When linseed oil is maintained at a high temperature without the addition of driers, a thick liquid is obtained. This is usually known as stand oil.

Blown oil is produced by blowing air through linseed oil without the addition of driers. It differs from stand oil in being only sparingly soluble in solvents and having a high acid value.

USE OF DRIERS.

The rate of drying of an oil is the measure of the rate of its absorption of oxygen from the atmosphere. It is found that this rate of absorption is increased by the presence in the oil of certain substances, to which is therefore given the name of driers. Though the exact mechanism of the reactions is not understood, the action is supposed to be the carrying of oxygen to the oil. Owing to their industrial importance it is essential to note the following facts:—

1. The accelerating effect of a drier is not proportional to the amount used. Usually the effect is not increased by amounts above 2 per cent by weight of oil, and any excess is definitely detrimental.

2. The drying of most drying oil continues slowly after the hard, durable, elastic film has been formed, so that the film eventually becomes less elastic and finally brittle. Artificial driers have the drawback that they accelerate this drying action as well as that in the initial stages, and therefore tend to shorten the life of the final film.

Driers are mainly salts of lead, manganese and cobalt, and also their compounds with drying oils.

BOILING LINSEED OIL.

Linseed oil is thickened by boiling in conjunction with metallic oxides, or the atmospheric air, to adapt it for use in the arts of life. It is usually treated with such carriers of oxygen as oxide of manganese, borate of manganese, borate of lead, acetate of lead, and

litharge. The oil should first be cleaned of mucilaginous matters and for this purpose it is usually allowed to stand in tanks for weeks or months as the case may be. The oil, is often, however, adulterated with resin oil so as to return a large profit to the manufacturers. But it not only retards drying, but also dissolves readily with a slight heat, thus causing the compounds made with such a mixture to feel clammy.

The usual method of producing boiled linseed oil is by the addition to the raw oil of from 4 to 8 per cent of concentrated liquid drier, that is liquid solution of metallic salt. In practice, the boiling is performed by first thoroughly heating and agitating the raw oil to expell all moisture and then adding the previously heated drier very slowly, agitating sufficiently to thoroughly mix the drier through the oil. One mode of agitation for expelling moisture is, after heating the raw oil in the tank to 250 degrees, to pump the hot oil from the bottom out and into the top. The heating is usually done by hot steam coils within the boiling tank, and the best location for these coils is around the sides of the tank and not closer than ten inches to the bottom. The oil is maintained at a high heat for some time after the addition and thorough mixture of the drier. The longer the temperature is maintained, the darker the oil becomes. The scum which forms on the surface, the residue left in the tank, and the scrapings from the filter cloths are disposed of separately.

PRACTICAL DETAILS.

It is advisable to boil the oil in an iron or copper pan of about 20 gallons capacity, with an enlarged mouth to prevent the oil from frothing and threatening to prime over. This pan is at a certain height furnished with a collar or circular flange which

supports it on the rim of a sheet iron furnace, fed preferably with wood charcoal. The pot being filled to the extent of half of its capacity with oil, and therefore containing about 10 to 11 gallons, the fire is lighted, and as soon as boiling commences the driers are added in small quantities at a time with constant stirring with an iron rod. The proportion and the nature of the driers used vary much. For the quantity of oil in the pot, any of the following mixtures may be used:—

2½ lbs. of red lead and 2½ lbs. litharge; or 2½ lbs. of litharge and 2½ lbs. sugar of lead; or 1½ lbs. of red lead and 3½ lbs. sugar of lead; or 1½ lbs. to 3½ lbs. of borate of manganese; or 2½ lbs. of hydrated oxide of manganese.

The driers are previously ground as finely as possible and the oil well stirred after each addition. As soon as the driers are all in and the frothing has ceased the pot is filled with oil just up to the neck, and the fire regulated so that the temperature does not rise above 220 deg. C., by means of a thermometer with metallic frame work. The operation is generally completed in three hours, during which time the driers are frequently stirred up from the bottom. The pot is then withdrawn from the fire, and the oil is set aside to clarify; or if it be desired to start boiling a fresh batch of oil it may be run into a galvanised wrought iron tank.

REFINING LINSEED OIL.

. 236 gallons of linseed oil is pumped into a copper boiler and run into it with rapid stirring 6 lbs. of sulphuric acid. Stir for 3 hours, then add 6 lbs. of fuller's earth mixed with 14 lbs. of hot lime, and again stir for 3 hours. Now run off the oil into a copper vessel containing an equal volume of water.

Boil for three hours, draw the fire and when the oil is cold, run off the water and let the mixture settle for some weeks.

DECOLOURISING LINSEED OIL.

To decolourise linseed oil use is usually made of a 30 per cent. solution of ferrous sulphate or potassium hydroxide solution followed by potassium bichromate and hydrochloric acid. Bleaching of linseed oil with chloride of lime and hydrochloric acid, or calcium bichromate and sulphuric acid, is sometimes employed, but the operation requires great care and is sometimes dangerous.

Decolourisation may also be effected by shaking the oil in a glass bottle with a 5 per cent. solution of hydrogen peroxide. It is then allowed to stand for some days with only occasional shaking. The oil clarifies and is poured off from the water at the bottom.

Decolourisation is also possible with potassium permanganate. For this purpose place 25,000 parts of oil in a large glass balloon, add a solution of 50 parts of potassium permanganate in 1,250 of water, stir well, allow to stand 24 hours at a gentle warmth, then add 75 parts by weight of powdered sodium sulphate, agitate well, add 100 parts of hydrochloric acid, again agitate, and allow to stand until decolourisation takes place. Wash the oil with water rendered milky, with chalk powder until free from acid, and finally separate the water, and filter off the oil through anhydrous sodium sulphate.

CHAPTER XV.

COTTON SEED OIL.

COTTON seeds for the purpose of oil milling may be classified into those, the husk of which is practically free from adhering cotton fibre and the other to which quite a considerable quantity of cotton fibre may be adherent. It pays the oil-mills to re-gin or delint it as a preliminary to treating it in the rolls and presses. A delinting machine as employed at an oil mill is almost identical with a cotton gin as employed by the cotton grower.

DECORTICATION.

In some cases it will be found advantageous to remove the husk or cortex of the cotton seeds before crushing and pressing them. In this way only the kernels, or "meats" as they are called, are pressed.

Decorticators have been devised to clean the cotton seed of the adhering cotton. The machines cut through both husk and kernel and a separator then divides the husk from the oily kernels, the husks being used as fuel or manure.

In the decortication of cotton seed there is always a certain amount of absorption loss arising from the husks absorbing a certain quantity of the oil from the kernels. Hence Bombay seed is generally treated without decortication or delinting. Experience shows that the maximum yield of oil can be obtained, even from Bombay seed, without decortication or delinting, provided the seed is thoroughly rolled, and the hulls and

lint or cotton fibre are by this treatment perfectly mixed and assimilated as an integral part of the meal.

PRINCIPLES OF OIL EXPRESSION.

The cotton seeds are first freed from all dust and dirt by being forced against a screen by means of a blower, so that all the heavy matters fall to the ground. The next step is to clean the seed, which is effected in a machine resembling a cotton gin, only that the teeth engage more intimately in order to remove the adherent cotton. The cleaned seeds are passed into a rotary cylinder containing equal number of cutters, which divide the seed into very small pieces. The hulls are thus separated from the kernels, forming a valued food for cattle. The kernels are pressed between rollers like those of a cane-sugar mill, when some of the oil runs out. The mass is then put into woollen press bags, laid between horse hair cloths covered with ruffled leather to enable the oil to flow more freely, and submitted to hydraulic pressure. The bags are exposed to warm pressing for about a quarter of an hour. This exposure suffices to force out all the oil, which collects in a channel, leaving only the dry kernels behind. These constitute the oil-cake of commerce. The oil is thereafter pumped into a tank, and if destined for sale in the crude state is filled into casks without delay. If, however, it is required for industrial application it is clarified and filtered or refined for storage.

THE PROCESS OF EXPRESSION.

The seed is usually passed through a set of Anglo-American crushing rolls. The seed is subjected to four passages through the rolls at a gradually increasing pressure due to the deadweight of the rolls immediately above. When the seed is thus broken, the cotton

fibre and the husk is still not thoroughly ground, and the rolled seed has to be passed through a second set of similar rolls. This produces a perfectly satisfactory meal from which the oil may be readily expressed.

Sometimes, instead of the second rolling, the rolled seed is passed under edge-runner stones, but this is not such a satisfactory process, because it is impossible to ensure that the whole of the meal is crushed by the stones.

The rolled cotton seed is now delivered to a heating kettle for the purpose of heating and moistening, or cooking. This kettle is steam heated, and fitted with agitating gear, to prevent the burning of the material, with its consequent discolouration. The upper kettle is connected to the lower one by an automatic mouthpiece, which ensures the meal being retained at the correct working level in the lower vessel, and thereby guarantees that the meal is delivered from the kettle at a uniform temperature, and that the moisture, which is added by means of the saturated steam, is also uniform. The best oil yield is obtained at 170 deg. F., whilst about 15 per cent. of added moisture should be present.

The next operation is to mould or form the meal in readiness for placing in the presses. This is done by hydraulic or steam moulding machines.

It is then placed between the press plates in the Anglo-American press. The pressure exerted is usually about 1,500 lb. per square inch on the cake. The maximum pressure is left on the cake for about 15 minutes, after which it will be found that the oil content of the cake does not exceed $4\frac{1}{2}$ to 5 per cent. After pressing, the edges of the cake are usually removed by a paring machine owing to the fact that these edges contain a considerably greater percentage of oil, and consequently the removal of the ragged edges produces

a cake with straight sides and of neat appearance, and permits of the excess of oil contained in the parings being recovered by subsequent pressing.

COTTON SEED OIL REFINING.

The principle underlying in the refining of cotton-seed oil is that the oil is first passed through a filter press to remove mucilage, etc., and then it is allowed to run into a storage tank. From this it is passed by gravity into the refining tank, where it is heated by steam until it reaches a temperature of about 140°F. Thereafter the oil is violently agitated by means of compressed air, the temperature meanwhile, being kept as near 140°F as possible. During the agitation caustic soda solution is run into the tank. As the solution is heavier than oil it tends to sink to the bottom, so care should be taken if intimate contact with the oil is desired. This can be done successfully by distributing the solution evenly over the surface of the oil and by vigorous agitation. When it has been ascertained by testing that sufficient caustic soda has been added to neutralise the free fatty acid, the charge is allowed to stand and settle.

After settling, which usually takes about 12 hours for complete sedimentation, the mucilage and other residue are drawn off into a pitch-lined tank and the clear oil is passed into washing tank where it is treated with hot water so as to remove all traces of caustic soda. The process may be repeated, if necessary. After this the last traces of moisture may be removed by boiling the oil in vacuum pans.

CHAPTER XVI.

CASTOR OIL.

THE distinguishing feature of castor seed as an oil-bearing substance lies in the fact that the portion which carries the oil is enclosed within two outer casings. The first step in the preparation of the seed for pressing is the removal of the outer pod.

The castor seed is covered with a brittle husk which is about 18 to 25 per cent. of the total weight, the kernel being a soft white mass exceptionally rich in oil. The extraction of the oil should therefore require special care of the oil millers.

Uncorticated castor seed can be treated to extract the oil without any difficulty but where it is desired to decorticate the seed before expressing the oil, then decorticating machines specially designed for castor seed may be used. These machines remove the shell of castor seed which is ordinarily speckled thinly and leave the white kernel ready for press.

The castor seed varies a great deal in size, and where this occurs it is necessary to grade the seed, say into three or four different sizes; this can be done by hand or by machine and the size is put through the decorticator separately, the machine being regulated to the size of the seed dealt with.

VARIOUS METHODS OF OBTAINING THE OIL.

Castor oil may be obtained from the seed by either of the three following methods:—

(a) by expression

V. O. I. 8.

- (b) by boiling with water
- (c) by the agency of alcohol.

In England nearly the whole quantity is obtained by expression. When the outer skin is first removed by rollers, previous to crushing and heating them, a clear and fine oil is produced, outer cuticle being applicable for manuring and other purposes. By this process the thicker portion, or stearine, which is now lost (by being mixed and left with the outer skin or cuticle), is obtained, and the oleaginous or thin portion of the oil is not coloured and deteriorated. The oil thus obtained can be purified by jets of gas, acids, and heat at about 150° to 160°F.

In America, the seeds, cleansed from the dust and fragments of the capsules, are submitted to a gentle heat, not greater than can be borne by the hand, which is intended to render the oil more fluid and therefore more easily expressed. The whitish oily liquid thus obtained is boiled with a large quantity of water, and the impurities skimmed off as they rise to the surface. The water dissolves the mucilage and starch, and the albumen is coagulated by the heat, forming a layer between the oil and water. The clear oil is now removed, and boiled with a very small quantity of water until aqueous vapour ceases to rise, and a small portion of the oil taken out in a phial remains perfectly transparent when cold. The effect of this operation is to clarify the oil, and to get rid of the volatile acid matter. Great care is necessary not to carry the heat too far, as the oil would thus acquire a brownish colour and acid taste.

In the West Indies the oil is obtained by decoction.

In some parts of Europe castor oil is extracted from the seeds by alcohol but the process is expensive.

COUNTRY METHODS.

In India the fruit is first shelled by manual labour, the seeds are crushed between rollers, then placed in hempen cloths, and pressed in the ordinary screw hydraulic press. The oil thus obtained is afterwards heated with water in a tin boiler until the water boils, by which means the mucilage and albumen are separated. The oil is then strained through flannel and put into canisters.

Four methods of expressing the oil are practised by the people of Bengal:—

(1) The seeds are crushed in a screw-press with horizontal rollers and the resulting pulp pressed in gunnies. The cold-drawn oil thus obtained amounts to 36 per cent.

(2) The seeds are roasted, pounded in a mortar and placed in four times their volume of water kept boiling. The mixture is constantly stirred, and the oil skimmed off as it rises to the surface.

(3) The seed is first boiled, dried for two or three days, then pounded in a mortar and boiled in four times its volume of water kept boiling and the oil skimmed as in (2).

(4) The seed is soaked overnight in water, ground in the morning in a gunny, and then squeezed within cloth till the oil has been obtained.

For cold-pressing, the kernels are pressed in gunny bags and the oil is thereafter bleached by exposure to the sun, which causes a sediment to precipitate. The oil is then filtered through vegetable charcoal and flannel bags. In some cases a fire is placed underneath the machine in which the bags are being pressed. This is said to increase the yield by 10 per cent but it is believed some of the noxious properties of the seed are then liable to pass into the oil.

In the United Provinces the seeds are first cleaned, roasted, pounded and then boiled in water. The oil rises to the surface and is skimmed off or decanted, and the boiling continued, the mixture being repeatedly stirred until exhausted of its oil, the last dregs rising to the surface as the fluid cools. The water mixed with the oil is next removed by reboiling until it evaporates; the impurities at the same time sink to the bottom, while the pure oil floats on the top and is decanted.

ACTUAL PROCESS.

In practice, about 15 seers of castor seed are cleaned and husked by beating with a stone, the result being 12 seers of kernels. That quantity is then placed in the ordinary wooden oil-mill. About one seer of boiling water is then added and the outlet of the mill plugged up until about half a seer of oil has been formed or, say, after the kernels have been ground for 10 to 12 minutes. Meanwhile, also, the contents of the mortar are constantly heated by means of a burning torch. The oil that collects from the mill is removed, heated, and poured back through the mill to help the further separation and this is repeated until the cake produced has been exhausted. The whole of the oil is then boiled to drive off water and cause the precipitation of the impurities. The oil is superior to that obtained by the boiling process. The yield is about 33 per cent.

MODERN METHOD.

Castor seed is usually worked twice, the first time cold and the second time hot. By the first pressing it is usually desired to extract the best cold-drawn medicinal oil. When this is the case, care should be taken that the seed is well cleaned before going to

the press. During the first pressing the seed is worked up in its natural state without any previous treatment, except cleaning, the seed being fed to the press whole, without preliminary crushing of any sort. No heat would be given to the cleaned but uncrushed material beyond that due to the atmosphere.

For cold pressing, use is made of a cage press of special construction. The kernels are delivered by means of a chute from a suitable receptacle directly into the pressing cage, each measure of kernels being 6 inches thick and separated by means of steel plates. They should not be subjected to a higher pressure than 35 cwt. per square inch on the cake as any higher pressure is found to cause considerable wastage. Care should also be taken to raise the pressure gradually but it is essential that maximum pressure is not applied for more than a few minutes.

Upon the conclusion of this operation, the cakes are broken and finely ground by means of rolls of the Anglo-American type. The meal is then taken for second pressing to the meal kettle where it is raised to a high temperature and thoroughly moistened by means of saturated steam. The presses used for the final expression are again of the cage press type, but in this case a pressure of 3 tons per square inch on the cake is required, and in addition, the length of time under pressure is considerably increased. For this reason, it is essential that the pressing cage should be filled to its maximum and in order to equalise the output of the preliminary press for first pressing, extra presses should be provided.

REFINING CASTOR OIL.

The refining of crude castor oil consists mainly in the removal of the albumen, free fatty acids, colouring

and odorous matters, and is conducted by first coagulating the albuminous matter and mucilage by steaming and filtering, then bleaching and deodorising by agitation in the presence of animal charcoal, and finally filtering and drying. The bleaching of the solvent extracted castor oil has been found to be a difficult operation. The colouring matter is held in colloidal suspension and has probably become very firmly fixed during the heating operation. It is most resistant to the action of bleaching agent.

I.

The process of refining castor oil consists in treating the oil with animal charcoal in the proportion of four to one by weight. Animal charcoal should be finely ground before it is mixed to the crude oil. The whole is put in glass or China jars and covered over with a lid and is then exposed to the rays of the sun for 15 days successively. Impurities are absorbed by the charcoal and on filtering refined oil is obtained.

II.

To clarify castor oil mix 100 parts of the oil at 95°F. with a mixture of 1 part of alcohol (96 per cent.) and 1 part of sulphuric acid. Allow to settle for 24 hours and then carefully decant from the precipitate. Now wash with warm water, boiling for $\frac{1}{2}$ hour; allow to settle for 24 hours in well closed vessels, after which time the purified oil may be taken off.

III.

Oil	20 parts.
Bichromate of potash	2 parts.
Sulphuric acid	3 parts.

Dissolve the bichromate in hot water, add the acid, then slowly put this mixture into the oil, agitating, if possible with hot air, or, if this cannot be done, a

rouser made of lead may be used. It should nearly fit the bottom of the tub, and be perforated with as many holes as possible. It must be worked up and down either by hand, or fitted to a mechanical stirrer, till the oil becomes pale green. Separate the oil from the chemicals and add $\frac{1}{2}\%$ oxalic acid with boiling water, agitate all the time till oil becomes clear, bright and odourless.

REFINING CASTOR OIL FOR MEDICAL USE.

The castor oil as obtained by cold expression is a whitish oily liquid possessing strong acrid odour. To remove this bad smell of the oil and at the same time to refine it proceed as follows:—

Transfer the oil to a clean iron boiler supplied with considerable quantity of water. Boil the mixture for some time and skim off the impurities as they rise to the surface, a clear oil is at length left upon the top of the water, the mucilage and starch having been dissolved by this liquid, and the albumen coagulated by the heat. The latter ingredient forms a whitish layer between the oil and the water. The clear oil is now carefully removed, and the process is completed by boiling with a minute proportion of water, and continuing the application of heat until aqueous vapour ceases to rise, and until a small portion of the liquid, taken out in a phial, continues perfectly transparent when it cools. The effect of this last operation is to clarify the oil, and to render it less irritating by driving off the acrid volatile matter.

But much care is required to carry out this operation so that not to push the heat too far, as the oil then acquires a brownish hue and an acrid peppery taste. After the completion of the process, put the oil into barrels and send to the market for sale.

DEODORISING CASTOR OIL.**I.**

Deodorising of castor oil may be effected by subjecting it to the simultaneous action of steam at 108° to 110°C. and of a saturated solution of alum or aluminium sulphate. The oil is kept at a temperature of about 80°C. until the sediment deposits, after which the clear upper layer, which is now odourless, is withdrawn.

II.

Charge 1 ton of oil in an open tank, turn on steam, and when at 120°F. stir in chloride of lime 19 lbs., animal charcoal 2 lbs., black oxide of manganese 28 lbs., and water 7 gallons. As soon as the oil is heated, add 25 lbs. hydrochloric acid, then add 20 lbs. sulphuric acid diluted in 1 gallon water, and boil slowly for 40 minutes. Turn off steam, allow to settle, and, when cold, it will be found to be free from smell.

CHAPTER XVII.

GROUNDNUT OIL.

THE groundnut, variously known as peanuts, money nuts, earth nuts, etc., contains a light outer shell which should be effectively removed and separated from the kernel before the oil can be expressed from it. The decorticators are therefore called into requisition and during the process a large proportion of the thin red brown skin which covers the kernel is eliminated. Sometimes after cracking, the kernels are brushed to remove the inner red skin with which they are coated, and afterwards again subjected to a blast of air from an aspirating fan to complete the separation. In the shelling process a fair proportion of the kernels are broken; where the nuts are to be immediately crushed and the oil extracted, this is no detriment. There are however special machineries which produce the shelled kernels unbroken, mainly for eating purposes, but these are not required at all for oil milling industry.

METHOD OF EXPRESSION.

Groundnut oil is usually recovered by expression. In the oil mills the nuts are first shelled by machinery, and the red seed coat is removed by winnowing. The nuts are then ground in edge-runners or by passing through rollers. On account of the high percentage of oil the material is subjected twice to a process of cold extraction in hydraulic presses and subsequently to a process of hot extraction. The cold drawn oil of the first extraction is of a higher degree of purity, is practically colourless and is used exclusively

as salad oil. The oil of the second cold extraction is somewhat inferior, is of a darker colour, but is still suitable for edible purposes. The hot drawn oil contains considerable quantities of dissolved colouring matter and other impurities which impart a dark colour to it, and is used only as soap stock or burning oil. Cold expression yields oil measuring about 30 per cent of the kernel whilst hot pressing gives an additional 10 per cent., leaving approximately 5 per cent. in the cake.

Groundnuts are occasionally treated in their undecorticated state. The most serious drawback to pressing the nuts in an undecorticated state is the fact that whilst the kernels are rich in oil, the shell, which is approximately 40 per cent. by weight of the whole nut, contains no oil, and in the event of the shell being ground up and pressed, naturally, during the operation, a considerable quantity of oil is absorbed which would otherwise be expressed.

It is a better policy to treat the nuts by Anglo-American machinery after mixing the kernels with 50 per cent. of groundnut cake. This materially reduces the percentage of oil in the meal passing forward to the heating kettle. At the same time, owing to fluid nature of the meal under pressure a considerable quantity of foots is made due to the passage of the meal with the oil during pressing. Cage presses are hence best for crushing groundnuts.

REFINING GROUNDNUT OIL.

The groundnut oil as expressed from the seed is liable to contain mucilage and albuminous matters, which produce turbidity in the oil. In order to remove these impurities filter the oil through a filter press; but before doing so treat the oil with 10 per cent. of its weight of fuller's earth, which should be dehydrated

by roasting prior to use. Mix thoroughly and then heat the mixture to 100°F, and maintain the temperature constant for about 15 minutes. Lastly filter the oil through filter press. Thus a clear oil is obtained but the odour of the oil is somewhat earthy. To remove this bad odour wash the oil with 1 per cent. solution of brine containing an equal amount of dry sodium bicarbonate.

For full details of bleaching with fuller's earth, reference may be made to page 87.

CHAPTER XVIII.

COCONUT OIL.

THE chief ingredient which gives coconut oil is copra the kernel inside the coconut fruit.

PREPARATION OF THE COPRA.

The splitting of coconuts to get the copra is a very tedious operation. In India this is done generally by hand as labour is very cheap here. But for quick results special machines for splitting the coconuts may be used. The nuts just as they are gathered are placed in the machine with the outer husk on. The machine cuts through the husk, shell and kernel at one operation. The machine is fitted with three revolving knives which are at an angle of 120° to each other. The nuts are fed into the hopper and thus delivered between the three knives, which are so formed that they drag the nuts through the machine and split them. The copra can then be easily separated from the shell.

DRYING OF COPRA.

The copra as generally received at the oil mill is in the form of lumps of big size. Sometimes however the material is found to contain an odd assortment of scrap iron which is removed by the magnetic separator.

It is imperative to dry the copra preparatory to the extraction of the oil. For this purpose manufacturers use copra drying floors specially constructed for the purpose. The floors comprise cast-iron grid plates, supported at some little distance from the

ground by "T" section steel bars carried in cast-iron brackets. Underneath the floor is a series of steam-heating pipes by means of which the copra is dried. Spherical ventilators are to be maintained for the efficient ventilation of the building. In India copra is dried in the sun and the sun-dried copra is considered to give better oil than the kiln-dried one.

DISINTEGRATING THE COPRA.

The dried copra is then to be ground in disintegrators. The grinding operation is generally done by percussion. The material to be treated is fed in at the periphery of the grinding chamber and falling on the extremity of the beaters, which are travelling at a very high velocity and by being beaten against the chilled iron liners in the upper part of bars of the screens which form the lower part of the machine, is thus pulverised. In some machines, such as the grist mills and disc mills friction between two corrugated iron surfaces is taken advantage of in thoroughly disintegrating the dried copra.

COUNTRY PROCESS.

On a small scale coconut oil is procured by first extracting the kernel from its outer integument or shell, and boiling it in water. It is then pounded and subjected to strong pressure. This being boiled over a slow fire, the oil floats on the surface. This is skimmed off as it rises and again boiled by itself. Fourteen or fifteen nuts will yield about two quarts of oil. A somewhat different practice obtains on the Malabar Coast. The kernel is divided into half-pieces, which are laid on shelves, and underneath is placed a charcoal fire in order to dry them. After 2 or 3 days they are placed on mats, and kept in the sun to dry after which

they are put in a press. When the oil is extracted by this method 100 nuts will yield about $2\frac{1}{2}$ gallons of oil. This is the method usually resorted to when the oil is required for exportation; the former, when merely used for culinary purposes.

MODERN METHOD.

The dried copra is in pieces of considerable size, containing from 50 to 60 per cent. of oil. It is, however, possible to obtain the maximum yield of oil by one pressing only, but to do this it is essential that the reduction of the copra should be perfect, and the meal produced of a uniformly fine quality flake, perfectly rolled in order to bruise the oil cells thoroughly.

MEAL MAKING.

The reduction of the copra to meal is usually done in three stages.

The first reduction rolls consist of two pairs of chilled iron rolls revolving at different speeds, each being grooved spirally in order to tear the copra rather than crush it; consequently, in its passage through these rolls the copra is subjected to two reductions. The second reduction is by means of a similar pair of rolls, but with finer grooves, the rolls in this case running at slightly higher speeds than those in the former set.

The final reduction of the broken copra to meal is by means of Anglo-American rolls, but it is essential that these rolls should be so constructed as to allow of a variation in pressure. The rolls are arranged vertically, and naturally the meal in its passage through the rolls is subjected to an increasing pressure, due to the dead-weight of the roll or rolls immediately

above. Provision is made whereby this deadweight can be relieved in order that, whilst the resulting meal is of a uniformly fine grade, it is possible to obtain this result without squeezing the oil out of the meal, otherwise there would be considerable difficulty in getting the meal to flow. It is therefore customary to arrange for the three upper rolls to be adjustable to meet the requirements in this direction.

The meal having now been suitably prepared, it must be subjected to high temperature, and moisture must be added to assist the flow of the oil whilst under pressure. For this purpose it is delivered to a double heating kettle, consisting of two kettles super-imposed, each constructed of mild steel, steam-jacketed, and each fitted with agitating gear. This latter is to keep the meal in motion whilst in the kettle, and prevent burning, which would result in discolouration of the oil. Between the upper and lower kettle is an automatic device which ensures a regular flow of meal to the lower kettle, to replace that which is continually being drawn therefrom. It is in the lower kettle that moisture is added in the form of saturated steam, and in order to thoroughly diffuse this moisture, it is usually added at atmospheric pressure, or as near to atmospheric pressure as may be possible. The meal, after passing through the kettle, will be found to be at a temperature of about 175 deg. F., and to contain about 15 per cent. of moisture.

EXPRESSION OF COCONUT OIL.

I.

The expression of the oil from the meal is by means of cage presses already described. The cage is filled with meal, camel-hair press mats and press plates, the thickness of the meal between each pair

of plates and mats being about $2\frac{1}{2}$ in. Owing to the large amount of oil contained in the meal, it is necessary that the cage should be fully packed with meal before pressure is admitted, otherwise the output would be considerably reduced.

The pressing cage being tightly packed with meal plates, etc., low pressure is admitted to the main ram. The necessity for the steady and regular admission of pressure at this stage cannot be too fully emphasised. It is well known that the oil flow having once ceased, it is quite impossible to obtain the maximum yield by the readmission of pressure, consequently pressure should be applied steadily from zero to maximum.

REFINING COCONUT OIL.

The process consists in boiling for a few hours the amount of oil to be refined with a 2 per cent. solution of sodium silicate, removing the soap formed and finally washing and drying the oil. The weight of sodium silicate used for a given quantity of oil depends upon the free 'fatty acid content of the oil and alkalinity of the silicate. The quantity of sodium silicate taken is such that its alkalinity is exactly equivalent to the acidity of the oil. Usually with an oil of 3 per cent. acidity, the quantity of sodium silicate of 140°Tw . required is 1.6 lbs. per 100 lbs. of the oil.

The oil, taken in a vessel with a tapering bottom and a stop-cock, is heated to about 80°C , and its equivalent of 2 per cent. silicate solution previously warmed to about 50°C , is poured slowly into it with vigorous stirring. The heating is continued for some time till the liquid comes to boiling. Then as the boiling goes on, water is poured in from time to time to make up for the loss by evaporation and this is continued for about two and a half hours. By this

time the issuing steam is found to have hardly any odour of coconut oil. At this stage, about 5 lbs. of powdered common salt are added, and the whole boiled for a few minutes to coagulate the soap formed. The liquid is then allowed to stand, and the emulsion of soap and silicic acid is carefully drawn off from the bottom. The residual oil is given two or three washings with hot water, till the wash liquid no longer gives any alkaline reaction. After every washing the wash water is drawn off from the bottom. The washed oil is then heated in a shallow dish with constant stirring to drive off any residual moisture.

The oil may finally be mixed with 1 per cent fuller's earth and filtered, when the oil is perfectly clear, bright and without any perceptible odour.

The product obtained by the above process is suitable for making hair oils and not for edible purposes.

The above process has been demonstrated by the Harcourt Butler Technological Institute, Cawnpore.

II.

Coconut oil of inferior quality may be greatly improved by being boiled with about 1 by 30th, of its weight of soda lye (sp. gr. 1.03) for half an hour with frequent skimming. Some 4 or 5 lbs. of salt per ton of oil are then added, and the boiling continued for another half hour. Another equal quantity of salt is then added, and the whole boiled up; and after standing till next day, the cleansed oil is run off from the brine and foots that have subsided.

III.

Sulphuric acid, in the proportion of three quarters to one and a half per cent. of the oil, acts as a depurating agent. It removes the water by which these substances were held in mucous matters themselves, thus

rendering them insoluble or otherwise effecting their destruction. Then allow the carbonized mass to settle as a flocculent deposit upon the bottom and remove the adhering sulphuric acid by washing and filter.

REMOVING RANCIDITY FROM COCONUT OIL.

Coconut oil becomes more or less rancid by keeping, owing to fermentative changes, atmospheric oxidation, or other causes. To remove this rancidity the oil is thoroughly agitated with a weak solution of sodium hydroxide, or a somewhat stronger one of sodium carbonate. The free fatty acids of low molecular weight will be thereby removed while the malodorous non-acid products of decomposition will be dissolved out so as to sweeten the oil. Diluted milk of lime and calcined magnesia are sometimes used in a similar fashion.

Any oil or fat is best protected from rancidity by keeping it in the dark in a vessel from which all air is excluded; again as cold has a retarding influence, the vessel should be stored in a cool place. As a rule, oils that have once become rancid, even if pretty thoroughly sweetened by such refining, are more apt to turn rancid again on keeping than fresh oils.

BLEACHING COCONUT OIL.

Coconut oil may be fairly bleached with animal charcoal. Use may be made in this connection of a percolator which is a cylindrical vessel with fine perforations at the bottom. It is placed on a stand, below which is placed a receptacle for collecting any liquid, dropping through the perforations. The false bottom of the percolator is covered with a layer of powdered and dried animal charcoal twelve to fifteen inches in thickness. The oil to be refined is gently

poured over the bed of charcoal and left to work its way through the same by gravity. During descent, the oil gives up its colour and odour to the charcoal with which it comes into contact. The process of percolation may be repeated till a point is reached when the percolating oil viewed in a layer one inch in thickness cannot be distinguished from clear water but would have a pale colour in a sufficiently thick layer.

The process is necessarily a slow one but it needs no attention and can be continued day and night. For a large output the dimension of the percolator may be suitably increased, or better, a series of percolators may be used.

When the charcoal loses its power of absorbing colour and odour after use for some time, it requires revivification.

DEODORISING COCONUT OIL.

Two methods are well known for the deodorisation of coconut oil :

(1) Wash out the odoriferous bodies with alcohol. This removes the fatty acids, and also such substances as phytostero. Some employ a joint process of washing with alcohol followed by treatment with charcoal.

(2) Pass high pressure steam at 6-8' atmosphere into the fluid oil for two or three hours; the non-volatile fatty acids left are to be removed by adding 0.25 per cent. of calcined magnesia, and the magnesium soap formed is then skimmed off the surface.

CHAPTER XIX.

MUSTARD OIL.

AS already explained on page 25, mustard seed is generally mixed with a fair proportion of niger seed before being subjected to cold expression in the *ghannies*, both bullock and power driven. Rotary *ghannies* have been fitted in most of the big oil mills in India but the yield of oil is not as good as in the case of that drawn by wooden *ghannies*.

ADDITION OF WATER.

In the process of pressing oil, addition of water to the charge plays a very important part, explains a bulletin issued by Village Industries Association.

The proportion of water to be added differs according to the variety of the seeds, their degree of ripeness, the time of the year and according as they are wet or dry. In the rainy season, there is moisture in the seeds and so the water required will be less than in winter, while in summer it is much more. The difference in this proportion is only about 5 to 7 tolas per lb. of charge, but all the same it is most important.

If they are pressed without adding water, no doubt, a certain amount of oil will be extracted but a large part of it will be left in the cake. The addition of water helps to extract the last possible drop of oil from the cake; therefore, if the water is less than required, the cake will be dry and will not give out all the oil. On the other hand if the water is more than required, the cake will become sticky and then also it will not give out all the oil. Thus it is most essential

to add the exact measure of water. Roughly, this measure comes to about $3\frac{1}{4}$ tolas of boiling water per lb. of mustard seeds. A rough test of knowing whether the water is sufficient or not is to take out a little of the crushed seed and make it into a pill. If it forms itself into a pill, the water may be taken to be sufficient ; if it crumbles, the water is not enough.

TIME TO ADD WATER.

Besides the quantity, the time when the water should be added must also be studied. As the water, besides helping to extract the oil, makes crushing easier, it should be added from the beginning and continued little by little as the powder becomes fine and dry. If too much water is added before the powder becomes fine, the latter begins to stick and takes more time to be fully pulverised. On the other hand, if water is not added at the proper time, the dry powder will keep on rolling in the pit without forming into cake, in which cases also, it will be take longer to finish the charge. A certain amount of water should be poured into the lower part of the pit, for the cake to form there, for, unless this cake is formed first, the upper powder will keep on rolling and, not become cake.

ACTUAL PROCESS.

About three-fourth the seeds that are put in one charge are allowed to be crushed first, keeping the remainder on the top of the mortar. After about five minutes when the seeds put in the pit come up, they are pushed back into the pit and about 25 tolas of boiling water is added, 15 tolas poured at the bottom and 10 tolas sprinkled in the upper part. Then after about ten minutes when the powder becomes dry an-

other lot of about 15 tolas is added in both the parts of the pit, and the remaining seeds are mixed with the powder. Again after about 15 minutes when oil appears and the powder begins to be formed into cake the last portion of water, about 20 tolas, is added in the same way as the second time. After this the oil is allowed to accumulate in the pit and the cake turned over with crowbar three or four times while the pestle is in motion and after about 15 minutes when the oil becomes completely free from powder, the drain is opened and the oil allowed to come down.

APPLICATION OF HEAT.

Heat is another time-saving factor in the extraction of oil. A certain amount of heat is produced by friction in the process of crushing and this can be supplemented by the addition of boiling water. Observation shows that even after the seeds are fully pulverised, the powder does not form into cake at once, but keeps on rolling in the pit. The addition of some sticky substance which is insoluble in oil but at the same time edible like gur or gum will help this powder to stick together and so to be pressed. The proportion of gur should be about 5% of the seeds, if gum $1/5\%$. While jaggery may ferment the cake if kept for a long time, gum is not likely to affect it in any way.

ADDITION OF SALT SOLUTION.

For pressing rape seeds, the addition of salt solution of about 20% strength, besides forming good cake, reduces the burning sensation which affects the eyes when the hot seeds are crushed.

The water that is added to the seed while pressing does not mix with the oil, but is sucked up by the cake. But if some cake powder is left in the oil, the powder

retains a certain amount of water in it. This water as also the cake powder makes the oil rancid after a certain time. If the seeds are of an inferior quality, not properly stored or not fully cleaned before putting into the charge, then also the oil will get rancid. To avoid this, powdered common salt, dried in the sun or upon fire, should be added to the oil in the proportion of 5 to 6%, and the oil should be allowed to rest for about a week. This will make the cake residue to settle down, when pure oil can be gently poured into another vessel leaving the settled powder at the bottom. The residue that is left after filtering off the clean oil should be again mixed with the seeds without keeping it for a long time to prevent it from becoming rancid. It should be added, a little in each charge, as owing to moisture contained in it, it is very sticky. Whenever such residue is added, the proportion of water should be reduced.

To accelerate the automatic circulation and turning over of cake in the pit, the cake should be turned over once or twice by digging it with the crow-bar while the pestle is in motion.

OPENING THE DRAIN.

The oil should not be allowed to run down into the vessel as soon as it comes, because at that time it contains a lot of powder and water. Such raw oil irritates the throat and becomes rancid very quickly. Time is not saved by opening the drain earlier because if oil runs down as soon as it is extracted the cake does not circulate. On the contrary, as the cake gets saturated with oil its circulation becomes speedy. Therefore the drain should be opened about 15 to 20 minutes after the pit becomes full of oil, the cake being turned over before doing so.

OIL CAKE.

If examined, it will be found that the cake formed at the lowest part of the pit contains the least of oil, that in the middle a little more and that at the top still more. This necessitates the circulation and stirring of the cake. The stirring is done by the automatic stirrer, but should also be done oft and on with a stirrer manipulated by hand. In the end, when the charge is about to be finished the stirrer should be removed and the cake be allowed to accumulate above the pit. This little quantity of cake contains more oil than the rest and should therefore be mixed again with the seeds and pressed. This saves time and produces a little higher percentage of oil.

On a large scale the oil may be extracted by expression as in the case of linseed.

Mustard oil is liable to adulteration with groundnut oil. Essence of mustard is often added in small quantities to give the adulterated oil a flavour akin to that of the real mustard oil.

In clarifying and refining the oil, the Thenard process, as explained on page 104 may be followed.

CHAPTER XX.

OTHER OILS.

DETAILED description of the expression of oils from other seeds will be only repetition of the processes already mentioned. We only give below the main points in connection with the milling of sesame, mohua, soyabean, poppy seed oils, etc.

POPPY SEED OIL.

Poppy seeds require only one pressing for oil extraction and may be treated exactly as linseed.

In India, the oil is expressed by the cold process, the yield being about 30 per cent. In France three stages are observed:—1st, cold expression—a very superior oil used for salads and paints; 2nd. cold expression—a lower grade edible oil but also used for paints; and 3rd. hot expression—a much inferior oil, mainly used for the manufacture of soaps. It is rendered perfectly colourless by exposure to the sun.

SESAME OIL.

Sesame oil is extracted by expression in the country or rotary *ghannies* as in the case of mustard. The oil is often adulterated with groundnut oil.

If treated by modern appliances the seeds are first cleansed and crushed. The crushed meal is then transferred to the kettle which would act as a collector and distributor if the material was to be worked cold the first time, or as a heater, collector and distributor if the material was to be worked hot for the first time. From the kettle, the material is passed on to

the presses, for the first pressing, the resulting cakes being ground up by suitable means, before passing to the kettle, for the final pressure.

The ordinary methods of filtering and bleaching with animal charcoal apply in the case of sesame oil,

SOYA BEAN OIL.

In Manchuria, the home of the soya bean, the oil is prepared by soaking the beans in water, crushing them and then extracting them in a press. This method of oil expression may also be practised with profit. But it must be admitted that the modern methods of extraction are the most suited, if only the question of funds can be adequately solved.

Two distinct processes of manufacturing soya bean oil are followed in Europe. The oldest, and in some respects the most satisfactory method, is by expression with the hydraulic press or expeller. The second method is by extracting the oil with some volatile-like benzine or benzol. The latter is more economical, but care must be taken to remove all of the solvent from the oil and the meal, especially from the latter if it is to be used for edible purposes. If meant only for fertiliser, complete removal of the solvent is not essential. When the meal is intended for fertilisation the extraction method is much cheaper because of the greater oil recovery.

PALM OIL.

The indigenous method of preparing palm oil consists in boiling the palm fruits and skimming the oil. But in this case the oil is useful for little beyond soap making purposes but provided due care is taken it is possible to deliver oil containing not more than 8 to 9 per cent. of free fatty acids.

To prepare oil of a better quality it is necessary to have the palm fruit freshly gathered from the bunches by hand without causing them any bruise.

It is next placed in trays and steamed in special ovens, after which it is treated in a macerating machine, which may be hand or power driven, according to the size of the factory. During this operation they are subjected to a steam spray, and a considerable quantity of oil is separated, but further treatment is necessary to obtain the maximum yield from the palm kernel.

Freshly-gathered palm fruit pericarp contains about 66 per cent. of oil, and consequently after steam heating and spraying, the mass of palm fruit is in a highly oleaginous state. The entire mass is therefore placed in a specially constructed steam-heated vessel and raised to an exceptionally high temperature, after which it is run into a centrifugal extractor which is revolved at a high speed, and after treatment it is found that practically no oil remains in the material discharged from the machine, which consists of fibre and nuts, the latter containing the well-known palm kernel. The nuts are put on one side to dry, after which they are cracked and the kernels separated mechanically.

This method of producing palm oil avoids entirely the use of hydraulic presses, and obtains a very high percentage of the oil contained in the pericarp.

Palm oil may be refined with bichromate of potash and sulphuric acid as described on page 118.

MAHUA OIL.

The mahuā oil is extracted from the kernel of the fruit. The kernels are taken out from the smooth chestnut coloured pericarp by being bruised, rubbed

and subjected to moderate pressure. They are then ground and the oil obtained by expression. In the Central Provinces the kernels are pounded and boiled and then wrapped up in two or three-folds of cloth and the oil is there-after expressed. The oil is now-a-days largely employed in soap making. Apparently the only limitation to the use of the oil is the want of enterprise in its extended production.

NEEM OIL.

Neem oil is obtained from the neem seeds. It is expressed in the country *ghani* which does not require any heating up of the seed. The seeds consist of shell 55·3 per cent and kernel 44·7 per cent. The seeds, if unshelled, give better quality oil. The kernels yield 48·9 per cent of oil.

PUNNAL OIL.

The Punnal (*Calophyllum Inophyllum*) oil expressed from its nut was used as an illuminant for a long time. The oil is at present being used to a small extent in soap-making, the supply in the Calcutta market coming chiefly from the Puri district in Orissa and also from the Sandwip and Hatia islands in the Noakhali district, Bengal. It may be noted that the shapes of the nut and the kernel of the Travancore variety are slightly ellipsoidal while those of the Sandwip variety are almost spherical.

At Sandwip the unshelling of the nuts is usually done by placing them on the hard floor and pressing them with a wooden board which is kept sliding over the nuts. This method gives a slightly larger output than that obtained by breaking the nuts by means of a mallet or hammer. It has been found that by breaking the nuts one by one about 2 lbs. of kernel

are obtained per hour. At Sandwip and Hatia the children and female members of the villagers do the shelling at their leisure time, and hence no account is taken of the cost of shelling. When however large scale plantations are organised, and all work including collection and shelling is required to be done by hired labour, the question of shelling the nuts quickly and economically will assume considerable importance.

The kernel immediately after shelling the nut has been found to contain 27 per cent. of moisture. It has to be dried before the oil can be expressed from it. The drying in the sun does not take more than eight days, while in the shade it takes place slowly requiring a longer time for completion. Further, in drying in the shade the kernel must be spread in a thin layer if decomposition and fungus growth are to be avoided. Attempts to dry the kernel in steam-heated chambers or vessels immediately after shelling result in the exudation from the same of a very sticky resinous substance. The steam-drying is, however, quite satisfactory when it is preceded by partial drying of the kernel either in the sun or in the shade as aforesaid.

After the removal of moisture by drying, the oil-content is found to be 72 per cent. of the dried kernel, which is about the maximum that can be found in any oil-bearing seed or fruit. The proportion of oil in the undried kernel is 56.7 per cent. and in the whole nut 38.7 per cent., the percentage of kernel on the whole nut being, on an average, 59.

The existing practice is to express the oil from the dried kernel by the country ghani but the results commonly obtained by the villagers are not satisfactory, the cake generally retaining fairly high percentage of oil. A sample of oil cake from Sandwip gave, on analysis, 19 per cent. of oil, so that with the country

ghani the actual yield of oil is only 53 per cent. out of total of 72 per cent. contained in the dried kernel. The above result of the analysis may be taken as typical of what happens in practice in villages where the oil is expressed in country ghanis by village workers.

The ideal method for obtaining the maximum yield of oil is to treat the kernel in the country ghani in the first instance and then to treat the resulting cake in the Expeller Press. It may incidentally be mentioned that on account of the spongy nature of the kernel very thorough expression cannot be effected in the hydraulic press.

The Punnal cake, like other oil-cakes, contains manurial constituents. The cake is however poisonous and cannot be used for such a purpose.

The purification is carried out as follows: 100 parts (by weight) of Punnal oil are taken in an iron kettle and 300 parts of water containing 9 parts of sodium carbonate are added to the oil. The mixture is boiled and a resinous substance is thereby extracted by the alkaline water along with the colouring matter of the oil. It generally suffices to boil the mixture for one hour. It is then allowed to cool and settle when the light yellow coloured oil rises at the top. This is decanted off or let out by means of cocks provided at different levels of the pan. The boiling of the mixture can be continued for one hour more or even longer but very little further improvement in the matter of the removal of colour can be effected thereby. The sodium carbonate solution contains the colouring matter as well as the resinous substance and is coloured dirty green and has a cloudiness. The decrease in the weight of the oil by this treatment is generally 15 to 20 per cent. of which a large portion can be recovered. The treatment with sodium carbonate as described above removes the free fatty acids of the oil as

evidenced by the very low acid value of the purified oil, and this is accompanied by a lowering of the density.

RAYNA OIL.

The Rayna or Pittiraj tree (Amoors rohituka) is found in large numbers, in what may be called the wild state, in the waste jungle lands. The seeds are small in size, the axis or diameter being seldom greater than three-fifths of an inch. The average weight of a fresh seed is 0.7 gramme, and 1,200 to 1,300 seeds weigh one seer. The exterior of the seed consists of a hard, brittle and thin shell of a dark colour. The shell is breakable and removable from the kernel underneath except for a small portion which sticks firmly to the latter and cannot be separated easily. The kernel is of the shape of a slightly depressed ellipsoid and is only slightly smaller in size than the seed. It has a dirty yellow colour but is covered by a very thin skin of a brown colour which can only be scraped off with a knife. The oil resides in the kernel but the latter has no oily feel and is moderately hard. The dried kernel can be crushed to a powder on pounding in a mortar.

The shell forms a small part of the total weight of the seed, being only 14 per cent. as against 86 per cent. made up by the kernel. Since, however, the shell is comparatively much harder than the kernel it cannot retain any appreciable portion of the oil when the unshelled seed is treated in the oil-press. There is, therefore, no absolute need for very rigorous decortication of the seeds. Further, since on account of its poisonous nature the cake of this oil-seed cannot be used as a food for cattle there can be no harm in its containing a little crushed shell.

It has been found by extracting the oil from the seed by the solvent method that the dried seed without

the shell has an oil-content of 56.2 per cent. which is equivalent to an yield of 43.2 per cent. on the undried seed in the shell.

The seed has a low moisture content, the unshelled seed containing only 9 per cent. moisture. For the expression of the oil in the country ghani or in the various oil presses it is necessary that the moisture of the seed should be completely driven out, for the oil expressed from the moist seed is liable to develop rancidity very quickly. The drying can be carried out as well in steam-heated chambers as in the sun. For the villagers, of course, the latter course is recommended. Since the collection of the seed takes place towards the end of winter, when there is little rain, the seeds can very well be dried in the sun. The drying should be done as soon after the collection as possible, for the undried seed deteriorates on aging. It has been found that the undried seed even in the shell is liable to be eaten up by worms. The drying is facilitated if direct contact is established between the kernel and the atmosphere. For this purpose, however, the total removal of the shell is not necessary. Since in the case of the mature Rayna seed there is invariably a gap between the shell and most part of the kernel it suffices if the shell is only bruised or partly broken, thus allowing passage for the moisture to go out during the process of drying. The shell is further loosened by the contraction, no doubt very small, of the kernel consequent on drying.

The seed dried in the above manner should next be ground to a meal of the proper degree of fineness if the oil is to be expressed in an oil-press. It has been found that a meal which passes through a 20 mesh sieve, i.e., a sieve having 20 holes per linear inch, is suitable for expression of oil in a small hydraulic press working at a pressure of 2 tons per square inch. The

country dhenki can be used advantageously for the grinding of the seed. For small quantities the household stone mill—the Janta—would do quite as well. In large-scale operations the end-runner mill may be used to crush the seed. For expression of oil in a country ghani, however, where the seed is subjected to considerable rubbing action in addition to pressure, the dried seed need not be ground before it is fed into the ghani.

The country method of preparing oil from the seed is to fry the same in earthenware or iron pans, crush the fried seed in the dhenki and then boil the crushed material with water for 5 to 6 hours. On settling, the upper layer which consists of the oil is carefully separated from the water. It is reported that one seer of oil used to be obtained from 4 to 5 seers seed, or an average yield of 22.5 per cent., which is only about half of the total oil-content of the seed. On the other hand, on treating the dried and crushed seed in shell in the small hydraulic press referred to about an yield of 38 per cent. of oil has been obtained, which is equivalent to an yield of 34.6 per cent. on the undried seed in shell, i.e., an excess of over 50 per cent. over the yield in the country method. The substitution of the hydraulic press by the country ghani would also lead to better results than those obtained by the boiling method.

The fresh oil has a deep red colour with a cloudiness and an odour which is neither strong nor very disagreeable. On standing, the oil becomes clear, and a solid fat separates from it and settles at the bottom, having a colour much less deep than that of the oil itself.

KARANJA OIL.

The oil of the seed of *Pongamia Glabra*, or Karanja, has been known in the Indian villages for a

long time. The oil, under the name of Pongam oil, is used in small quantities in a few soap factories in Southern India for the manufacture of settled soap.

The Karanja is found throughout Eastern India, from the Central to the Eastern Himalayas, and in Ceylon and Malacca. The fruit consists of flat beans of sizes varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in length and $\frac{3}{4}$ to $1\frac{1}{4}$ inches in breadth, each bean generally enclosing one seed of the shape of a disc. The oil resides in the seed.

The average proportion of kernel to whole bean is, 41.3 per cent. The amount of moisture in the undried seed is 26.2 per cent. The proportion of dried kernel to whole bean is 30.5 per cent. The content of oil in the dried kernel is 29.2 per cent. The yield of oil by the solvent method amounts to 8.9 per cent. on the whole bean.

The seed can be pressed very well in the hydraulic press. The oil expressed has a yellowish-brown colour which appears reddish-brown in thick layers. A sample of cake from a small hydraulic press working at 2 tons per square inch contained only 6.5 per cent. oil, indicating the expression of 77 per cent. of the total oil-content of the seed. The country ghani can be used for the expression of the oil as is usually done in the villages, but the yield of oil is poor.

Karanja cake is poisonous and hence cannot be used as cattle food. As fertilizer, however, it should be largely used. Compared with mustard cake it is richer in nitrogen and should command price equal to, if not higher than, that of the former.

KUSUM OIL.

The Kusum tree is found in its natural state in the parts that form the borderland of Chotanagpur, its

home being close to that of the Sal (*Shorea robusta*) which it resembles in habit. The oil resides in the seed, i.e., the stone of the fruit which is a nut of the shape of an ovoid more or less half an inch in diameter. The fruit is generally one-seeded, but two-seeded fruits are by no means rare. It has an outer shell and below that a pericarp surrounding the seed.

The kernel of the seed is moderately hard and oily to the touch and is enclosed in a thin, hard, easily breakable shell of a non-porous nature. The whole fruit is seldom sent to the market, the supplies mostly consisting of clean seeds of a reddish-brown colour and without the pericarp and the outer shell. The kernel forms 22.2 per cent. of the whole nut, but of the seed as it comes to the market it forms no less than 69 per cent., the balance of 31 per cent. being the weight of the thin shell. The seed has an average weight of 0.46 gramme. The kernel has a moisture content of 3.55 per cent. removable by steam-drying for 5 hours. The dried seed without the shell yields on extraction with petrol ether 65.7 per cent. of fat which amounts to 42.9 per cent. of the seed in the shell. * The high fat content of the seed offers difficulties in its preliminary disintegration preparatory to expression. The rupture of a number of oil cells consequent on the initial pounding of the seed liberates a quantity of oil that enables the partially crushed material to form sticky lumps that cake to the side of the pestle and interfere with its pounding action. It is an advantage in such cases to express the oil in two instalments, the material being thoroughly disintegrated after the first expression.

The yield of oil is slightly higher from decorticated seeds than from undecorticated ones, but the cost is also higher in the former case, for in the absence of proper machinery the decortication has to be done by

hand, thereby enhancing the labour charges. The shell, as already stated, is not too hard to be easily pounded, and the whole seed can very well be reduced to a pulp in the ordinary dhenki. Since the shell is non-porous in character it cannot retain much oil by itself, but unless finely disintegrated it may stand in the way of the easy flow of the oil from the cells when the seed is pressed in a hydraulic press. The intermediate crushing between the two expressions should therefore be done very thoroughly. The results of expressing oil from the undecorticated seed in a small hydraulic press working at a pressure of 2 tons per square inch show that the yield of oil is about 28.3 per cent. which is equivalent to 43 per cent. on the dried kernel devoid of shell. This may roughly be taken to be the normal yield by the use of the hydraulic press.

The expressed oil is yellowish brown in colour and when allowed to stand a solid fat of a much lighter colour separates and settles at the bottom and remains so in the warmest weather of Calcutta. The oil has a none too pronounced odour of a non-disagreeable character.

Another important property of the soap of Kusum oil is the immunity that it enjoys from rancidity. This property enables the oil to be included in the composition of charges for toilet soaps with good effect.

SULPHONATED OLIVE OIL.

Take 100 lbs. of olive oil in a suitable wooden vessel and allow the temperature of the oil to come down somewhere about 10°C. Then weigh into a stoneware jug 6½ lbs. of pure sulphuric acid and cautiously run into the oil, the latter being constantly stirred to prevent over-heating and decomposition. This addition is the most important part of the process and that upon which success in making a good oil de-

pend. It must be made slowly and in small quantities at a time, so that it may take several hours to make the total addition. During this operation, the temperature of the reacting mixture must not be allowed to go above 16°C ., otherwise a dark oil will be formed containing decomposition products. When all the oil has been added, the mixture is allowed to stand covered up for about a day, when it is ready for washing.

This is best done with a strong solution of common salt, which is made up in a separate vessel

The salt solution is added to the oil and the whole well stirred together when the mixture is allowed to stand for separation. The oil comes to the top of the liquor and the salt solution can be separated off by means of a syphon, or if convenient this washing should be done in a wooden vessel, having fixed at the bottom a draw-off cock for separating the washing of salt solution. This washing operation is repeated several times, when finally the oil is allowed to further stand, so that as much water as possible will settle out. The final process is neutralising, for which can be used a caustic soda solution or diluted ammonia. Caustic soda solution is added in small amounts at a time, stirring after each addition, until the oil reacts neutral to litmus paper, that is, it changes neither the colour of a red or blue paper. The resultant oil is then ready for use. The actual end point of the neutralising can easily be judged after a few trials, as the oil suddenly goes quite clear.

PEANUT OIL.

To refine rancid and better peanut oil or oil of almonds make an emulsion of the oil with a potash dissolved in twenty times its weight of water, and agitate. In an hour the emulsion is destroyed with

sulphuric acid and diluted with ten times its weight of water. The reforming process commences immediately; the oil appears on the surface, and after a few hours of rest is completely separated. The oil is then decanted and filtered.

PURIFICATION OF OILS.

Heat the oil with 2 to 3 per cent. of sodium disulphide to 77° to 95°F and stir until all the sulphurous acid has escaped.

CHAPTER XXI.

HYDROGENATION OF OILS.

A new industry, of far-reaching consequences, has recently been started in the utilisation of fats and oils, which up till now, had a very restricted application in the arts and industries. This new industry is known as the hydrogenation of fats and oils. Fats and oils, which on account of their unpleasant odour or other inherent physical or chemical defects were regarded as unfit for many industrial purposes, have been transformed by this process into varieties which have a ready market and the demand for which is increasing every year.

USES.

The first and the foremost use of these hydrogenated products is in the manufacture of soaps. Fish oils, whale oils, although very cheap, were not used for soap-making on account of their unpleasant odour. But when hydrogenated, these undesirable properties entirely disappear and these oils can give soaps of the finest quality.

Another important use of these products is in the dressing of leather. It is well-known, that to impart a soft and supple touch to the finished leather, the tanners usually drub them with vegetable oils which are rather costly. But in hydrogenated fish oils, they have found a material which is eminently suitable for their purpose and also very cheap. Very satisfactory results have also been obtained by the use of hydrogenated oils as lubricants.

As already stated before, hydrogenated oils are finding a rapidly increasing market as a substitute of "Ghee." It has been placed in the market as artificial ghee at a price considerably lower than animal products. But the unscrupulous vendors might easily pass it off as butter fat to the ignorant villagers. Some sort of legislation is required to check this practice. For, although the artificial product may not contain any ingredient that may prove harmful to the system, it is lacking in the glycerides and other organic bodies, which are present in butter fat and which are known to be beneficial to the human system.

PRINCIPLE BEHIND HYDROGENATION.

The shortage of butter supply during the War stimulated enquiry as to whether fluid oils can be converted into solid fats or not. "On the face of it," writes Mitchell, "the problem appears simple, for the typical liquid fatty acid, oleic acid, only differs in elementary composition from the technical solid fatty acid, stearic acid, in containing two atoms less of hydrogen, and the whole problem is to make the oleic acid to absorb hydrogen and become stearic acid or stearine." But how the addition of the hydrogen atoms can be effected was a great problem to the chemists. Hydrogen, under ordinary conditions, does not enter into chemical reaction with insaturated fats and oils like oleic acid, etc. But it is observed that if a third substance, *e.g.* nickel or palladium is added, in small quantity, which is known not to react either with the oil or with the hydrogen, the gas is rapidly absorbed in its presence by the oil, forming a product endowed with altogether different properties, both chemical and physical, which in the present instance is the hydrogenated oil or solid fat. Such a substance which thus accelerates the rate of reaction between two others,

without suffering any change in the end, is called by chemists a *catalytic agent* or a *catalyzer*. Although it is generally found that the catalyzer can be recovered unchanged at the end of the operation, yet opinions are divided among the leading chemists, whether a catalyzer does or does not enter into the reaction at all. The subject is too extensive to be discussed here in detail but this much is certain, from a study of the modes of actions of catalyzers which have received a rational explanation, that a catalytic agent, first of all, forms a compound with one of the reacting bodies, before bringing about the final result. In this particular case nickel is used as a catalytic agent, which first combines with hydrogen to form a definite compound. The new substance at once decomposes and sets free the hydrogen to attack the oil.

NICKEL AS A CATALYSER.

For the purpose of the hydrogenation of fats and oils, the number of available catalysts is fairly large. But from a practical standpoint the choice is restricted to two only, nickel and palladium, although it is quite true that the operation can very well be carried out with platinum, copper, iron, gold, etc. Of these two, again palladium can easily be eliminated on account of its high cost, though in some respects it has some advantage over nickel, which is now universally employed for hydrogenation of fats on account of its low cost and efficiency.

PREPARATION OF THE CATALYTIC NICKEL.

The preparation of a satisfactory nickel catalyst requires considerable manipulative skill and technical experience. Unless this is obtained in a pure state, the final product obtained after hydrogenation will never be of good quality.

PREPARATION OF NICKEL OXIDE.

The starting material for the preparation of the oxide of nickel is generally a soluble salt of nickel, most commonly the nickel nitrate. The nickel oxide may be prepared by igniting the nitrate. The operation is generally conducted in nickel vessel and the nitrate is heated, till the evolution of fumes ceases.

Nickel oxide may also be prepared as follows:—The nitrate of nickel is dissolved in water and caustic soda solution is added, when nickel hydroxide is precipitated. This is filtered off and the precipitate is repeatedly washed with hot water on the filter, till the wash water is neutral to litmus. This operation is of the greatest importance, as any impurity in the precipitate will render it quite inactive. The precipitate is then dried between 100° to 110°C and after this ing operation, it is ready for the next stage.

It thus appears from the details given above, that the first process is by far the easier but there are some technical details for which the manufacturers prefer the second one in spite of its obvious disadvantages. In actual operation it has been found that the catalytic agent prepared from the nickel oxide obtained according to the first process is not in so fine a state of division as that obtained by the second, with the result that efficiency of the latter is much greater than that of the former. Again, catalysts made from nickel oxide without a supporting medium, weight for weight, is hardly as efficient as when the active surface is increased by the use of a carrier. Hence there are many methods for the production of catalyzer with a great diversity of carriers, ranging from pumice stone, kieselguhr to charcoal and saw dust. As it is impossible to employ these carriers when the first method is used, all manufacturers prefer the second process. The

actual operation is carried out as described below: The solution of nickel nitrate is made and the carrier usually added to the solution is fibrous asbestos or kieselguhr or pumice stone. The solution is then made alkaline and treated as described before.

REDUCING THE OXIDE.

The next operation is then reduction of nickel oxide to metallic nickel. The reducing agent employed is hydrogen in the purest state available. Purity of hydrogen is a most essential factor in manufacturing hydrogenated oils, otherwise the final product will be contaminated. Success in this industry also demands a cheap supply of hydrogen. The principal methods of preparing hydrogen for the purpose have been discussed later.

The reduction of nickel oxide begins at a temperature of 220°C but even at a temperature of 270°C the reduction is not complete, after prolonged action. When the reducing operation is conducted at a temperature between 300° - 325°C the action is fairly rapid. It has been found that the lower the temperature at which the reduction is conducted, the more catalyst is also rendered more sensitive towards the external influences. Hence the preparation of the catalyst is conducted, not only with respect to the degree of activity but also to longevity. In actual practice, the oxide with the support is placed in a vessel, provided with a very efficient stirring arrangement or into a revolving vessel, which can be maintained at any desired temperature for any length of time. After the catalyst has been introduced, the air inside the vessel, is displaced by passing a current of pure and dry hydrogen gas; and after about 1 hour, the temperature of the vessel is gradually raised and maintained between 300° - 325°C . The adjustment of temperature is

generally done by having the vessel immersed in an oil-bath. During this period of heating, the contents of the vessel must be kept constantly agitated, so that every part comes in contact with the hydrogen. When the reduction is complete (which generally takes 4 to 6 hours) the vessel must be kept closed, so that the catalyzer does not come in contact with the air. If by any chance there is a leakage of air into the reduction vessel, the activity of the catalyst is greatly impaired.

METHOD OF HYDROGENATION.

The catalyst being now ready, the next operation is the treatment of the oil with hydrogen in the presence of the catalyst. There are several types of apparatus for this purpose which have all the same object in view, *viz.*, to secure intimate contact of the oil, the hydrogen and the catalyst. One specific method is to spray the oil mixed with the catalyst in a chamber filled with hydrogen, to pump out the oil and repeat the operation till the requisite degree of hardness is reached. But when pumping in or pumping out the oil and the catalyst, they should never be allowed to come in contact with air. In another and simpler form, the oil is poured into the vessel in which the catalyst was prepared, the vessel is heated to 175°-190°C on an oil-bath and pure and dry hydrogen is allowed to pass, the contents being very violently agitated to secure an intimate contact of the reacting substances. The operation is allowed to go on until the proper degree of hardness has been acquired.

FILTRATION OF THE PRODUCT.

The next operation consists in filtering off the support and the catalyzer, after which the oil can be stored or treated further as required. For the purpose

of filtration, some sort of filter press is essential, otherwise the operation becomes long and tedious. It has been found by the careful analysis of samples of hydrogenated oils, that a certain quantity of nickel (very small indeed) is invariably present. This is due to the presence of a certain percentage of free acid in the oil employed. When the hydrogenated product is intended for human consumption, the presence of nickel is objectionable and attempts should always be made to start with a sample which contains no free acid, which means that the oil should be previously refined.

CATALYZER REDUCING DEVICE.

In this connection mention may be made of the latest devices and improvements made in manufacturing hydrogenated oils.

A simple and efficient type of catalyzer-reducing device consists of a reducing drum fitted in a brick structure. The drum is rotated by means of a sprocket. There are stuffing boxes which admit of rotating the drum without disturbing the gas inlet and outlet. The catalyzer is admitted and withdrawn through an opening. After the reaction the hopper is coupled to the flange of the opening. The bottom of the hopper clips below the surface of the oil contained in a receptacle beneath. Hydrogen is passed in through a valve and the air is hereby expelled from the hopper. The valve of the reducing drum is opened and the well-cooled catalyzer allowed to fall into the oil with which it should be thoroughly mixed, thereby the catalyzer is effectively sealed from the air.

HYDROGENATING PLANT.

The arrangement of the apparatus for carrying out the process is as follows:

The catalyzer as obtained in the previous operation is transferred to the large agitating tank to which a measured amount of oil is poured in. This tank is in direct communication with the hydrogenerator by means of steel pipe so that the catalyzer and oil may be pumped from the agitating tank into the hydrogenerator by means of the rotary pump which takes the liquid from the bottom of the tank and pumps it through the inductor where the hydrogen drawn from the gas space at the top of the hydrogenerator is mixed with them. The whole mixture is then ejected through the distributor at the bottom of the hydrogenerator. The tank is provided with an outlet for testing samples of oil from time to time to ensure the end of the operation. At the termination, the oil is drawn off through another outlet into a large tank heated by steam coils. From this tank the mixture of hydrogenated oil and catalyzer is pumped into the filter press where the catalyzer is removed, for it is injurious to human health. The oil is finally run into cooling tank to solidify to a hard mass.

OUTLINE OF THE PROCESS

The raw oil often contains moisture, which greatly hinders hydrogenation. The oil is first of all heated in an open tank provided with a mechanical agitator and steam heating coils. By this the major portion of moisture is removed. To secure the final and complete desiccation the oil is pumped into vacuum pan where it is boiled at a low temperature. The desiccated oil with catalyst is heated in an atmosphere of hydrogen inside a closed vessel fitted with a mechanical stirrer. The oil and hydrogen are brought into intimate contact and at the end of three to four hours the absorption is found to be complete. The temperature at which the work is carried on is of great importance. It ap-

pears that for any given pressure of hydrogen inside the autoclave, there is a definite temperature which must be reached before the absorption begins. At atmospheric pressure this temperature appears to be about 250°C . In practice such a temperature would almost certainly result in the hardened oil being discoloured. To avoid this some temperature approximating 200°C must be used. The pressure of the hydrogen has to be increased as the temperature is decreased.

A normal working condition is a temperature of 170° to 180°C in conjunction with a pressure of 70 to 80 lbs. per square inch.

When absorption is complete the oil is run out of the autoclave, cooled, filtered and allowed to solidify.

PROSPECTS.

Proposals are being made, in various parts of India, for erecting factories for the hydrogenation of fats and oils. India's resources of vegetable oils are extensive but it seems a pity that these are exported abroad only to come back in the form of hydrogenated products, at a price approximately twice as much. But an important point must be taken into consideration. The manufacture of these hydrogenated products requires a cheap and enormous supply of pure hydrogen. The gas must be free from sulphur, chlorine, arsenic, phosphorus and oxides of carbon and nitrogen with which the gas is generally contaminated. At the present stage of our industrial progress, a cheap supply of hydrogen is impossible. We discuss the point in some detail here.

GENERATION OF HYDROGEN.

The methods employed for the preparation of hydrogen for industrial purposes are many but the following are some of the most important:—

1. By passing steam over spongy iron.
2. Electrolytic method.
3. Liquefaction of water gas.

HYDROGEN FROM STEAM.

When steam is passed over hot spongy iron, in a suitable furnace, hydrogen is produced. This process can only be said to have some chance of being worked successfully, if the technical details can be mastered. For even in Europe, there are many countries not in favour of this process. A risk also accompanies this process. If by any means, the hydrogen obtained is not pure, the whole operation will be unsuccessful.

The process devised by Lane may however be followed with fair results. The method consists in decomposing the steam by means of reduced iron and in reducing the resulting iron oxide by the components of the water gas.

ELECTROLYTIC METHODS.

When an electric current is passed through water containing a small quantity of sulphuric acid, the water is decomposed into its elements. Oxygen is liberated at the anode while hydrogen escapes at the cathode. This process is sometimes called "the electrolysis of water," but the expression is a misnomer, since the acid plays an essential part in the reaction, pure water being practically non-conductor of electricity.

Under manufacturing conditions, hydrogen produced by the electrolysis of acidified water usually contains oxygen, an impurity liable to produce dangerous explosions. To obviate this, diaphragms are introduced between the electrodes, though this increases the electrical resistance of the cells.

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In electrolysing sodium chloride solution, caustic soda, chlorine and hydrogen are obtained. Consequently enormous amounts of hydrogen are liberated in the manufacture of caustic alkalis by this method.

The electrolytic method is fairly possible when hydrogen is obtained as a bye-product in some other industry, as in Castner-Kellner process for the manufacture of caustic soda from brine. But in India, with the high price of electricity, these operations are impossible. It is only practicable in those countries possessing natural water power. An instance will not perhaps be out of place. So far as our information goes, the cost of generating one unit of electricity by the Tata Hydro-electric Scheme is about 6 times that in Norway and Sweden.

LIQUEFACTION OF WATER GAS.

The third process consists in the liquefaction of water-gas and its fractional evaporation. But the manufacturer in this case should find some market for his carbon monoxide. The time is very distant indeed, when the people of all countries will dispense with the wasteful method of burning coal in open grates and all the coal will be gasified and delivered to consumers in pipes like filtered water.

The method of Linde-Caro of generating hydrogen is based on fractional distillation of the liquefied components of water gas. The resulting hydrogen is of 87-98 per cent. purity and is brought to 99.5 per cent. by being passed over soda-lime heated to 180°C.

SUITABILITY OF THE PROCESSES.

In India the following processes can be advantageously employed for the manufacture of hydrogen:—

(1) From water gas and (2) by the electrolysis of

water. The first process is found to be cheaper but the plant required must be of a very large size and hence the initial cost for installation will be too high. Although apparently the water gas process gives the cheapest hydrogen, the handling of the apparatus, its repairs, etc., are more troublesome and consume more in the form of trained and skilled labour so much so that only for the largest installation this is recommended.

As the industry depends primarily on cheap production of very pure hydrogen on a commercial scale it will be necessary to find out which of the hydrogen generating processes is suitable in this country. Obviously distinction must be made between various centres of this vast country, as there may be places where oil is cheap but hydrogen costly. On analysis of the various processes for the generation of hydrogen, coal is ultimately the fundamental agent for the production of hydrogen, whether it be by the electrolytic process or by the water gas process. In this respect Bengal therefore with its vast coal-fields and tolerably rich oil-seeds industry offers the most suitable site for the establishment of the hydrogenation industry. Madras could be also a suitable centre with her rich source of oil-seeds. The cost of hydrogen production is naturally the more in this province due to the absence of cheap fuel, but the hydro-electric power of that province offers a suitable solution.

